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THE SIEGE OF ALEXANDRIA BY JULIUS CÆSAR.

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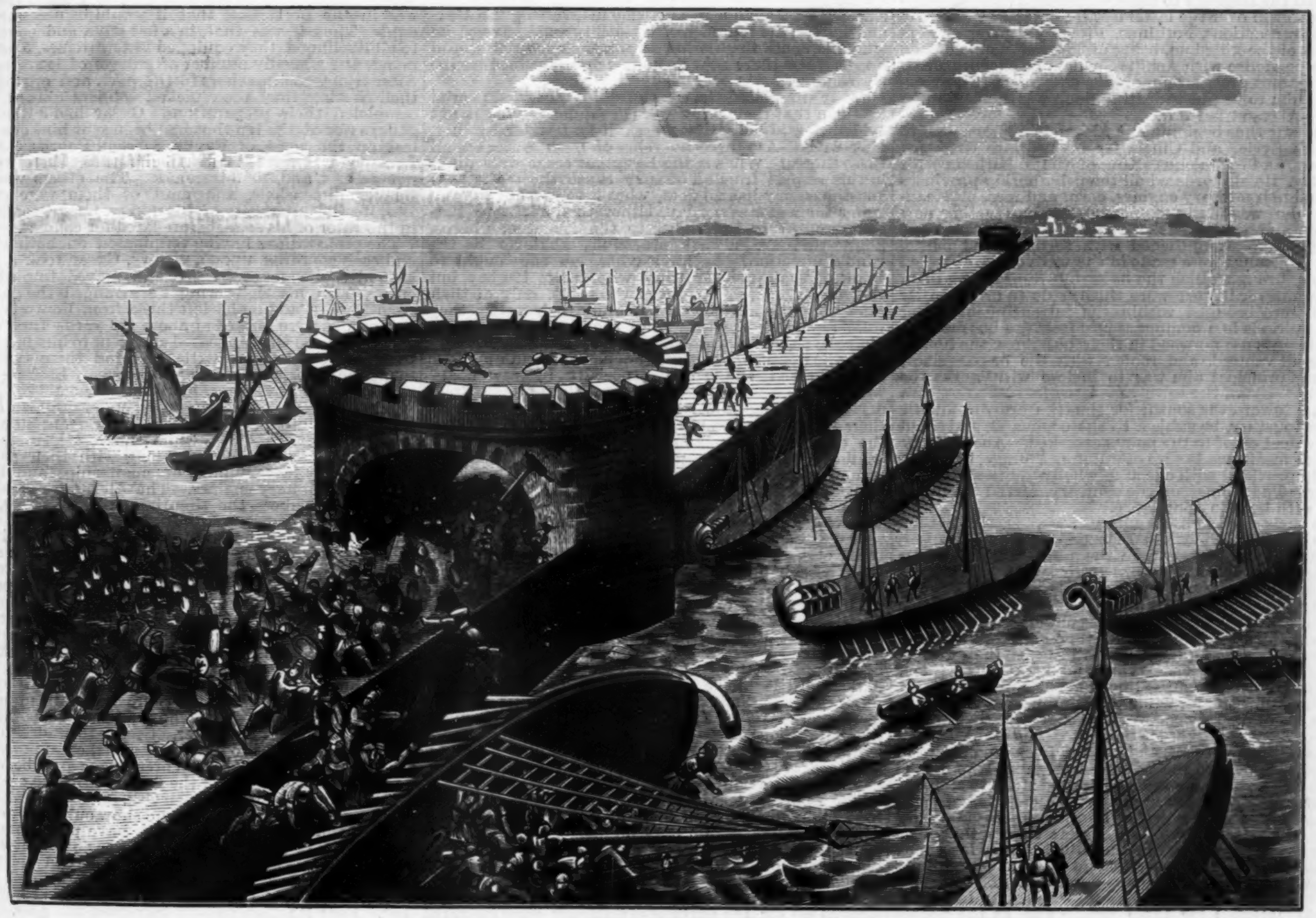
IT was not only in struggling for the empire of the sea that the fleets of the ancients played a great role, but also in transporting armies and in serving as auxiliaries in operations for which their dimensions, draught, and armament adapted them. The siege of Alexandria by Cæsar is one of the pages of history in which this double role of the navy is best seen. Up to the present time but insufficient explanations have been given of the narrative contained in the third book of the Commentaries. In order to render this intelligible, it is necessary, along with what we see and what we know, to restore the places as they were twenty centuries ago. A few suppositions will be necessary, and the reader will judge of their probability.



SIEGE OF ALEXANDRIA BY CÆSAR.

Alexandria was built upon the edge of the sea, and was surrounded by a continuous rampart. A swampy plain extended to the south of its eastern part, so that the circumference had a re-entrant form. Opposite the city, in a direction parallel with the coast, there was a narrow island called Pharos, which was about two miles in length. In the prolongation of this island, on the southwest side, there was a chain of reefs and shoals, interrupted by narrow passes that ran toward the coast. Starting from the northeast point, a second line of reefs and shoals limited the *ports* that we to-day would call the *roadsteads* of Alexandria (Fig. 1).

Ptolemy Philadelphus had the tower of Pharos constructed by Sostratus of Cnidus. Almost at the same time two jetties were constructed, one of them, J′ J′, protecting the northern part of the anchorage, and the other, J J, connecting the island with the continent. This last mentioned jetty was divided into three parts by two bridges, P P′, which were defended by two towers (*castella*). It is probable that, in order not to change the current, the intermediate section of the jetty, J J, and the entire jetty, J′ J′, were built of piles, which would explain the total disappearance of the last work.

In the course of time, and perhaps through the final union of the island with the mainland, sand accumulated, and there formed a very wide isthmus, upon which modern Alexandria is situated. We may grant that, as long ago as Cæsar's time, the southern part of the jetty, J J, had already formed a sandbar, S S, of a certain extent upon the left side of the work.

The effect of the two jetties was to improve the anchorage at Alexandria, and to divide into two the large port and the new one. It was in the former of these that the Alexandrians fought, and it was upon this that was situated the royal arsenal under whose walls they took refuge. Cæsar, taking the pass of Pharos, approached the new port, and landed at a defended spot that communicated with the citadel. The new port likewise had an arsenal, but it was probably not so important a one as the royal. Current service between the two maritime establishments was effected through the bridges, P and P′, which allowed of the easy passage of rowboats, and even of dismantled galleys.

There is a poetic legend which says that Cleopatra, escaping in a row boat, bribed the guardian of Pharos, and got him to loosen the chain that closed the entrance to the port. If the fact is true, the queen escaped through one of the passes, P P′.

Cæsar's Commentaries on the Civil War (Translation).—Cæsar having remained in Asia for a few days, learned there that Pompey had gone to Cyprus. Thinking that his adversary was taking a direction toward Egypt where he had partisans, and where he could find succor, he went to Alexandria with a legion that he had brought from Thessaly, a second legion that he had ordered from his lieutenant, Q. Fufius, in Achaia, and 800 cavalry. These troops were transported by ten galleys from Rhodes, and a few from Asia. In the ranks of the two legions there were more than 3,200 men. The others, wounded or exhausted by fatigue, remained on the road. But Cæsar, counting upon the influence of his name, and not deeming it possible to meet with dangerous enemies anywhere, did not hesitate to start out with so weak an army. At Alexandria he learned of Pompey's death. The first clamors that he heard upon setting foot upon land were those of the soldiers that the king had left in garrison in the city. Here he found himself surrounded by a multitude of people irritated at the sight of the fasces that he caused to be borne before him, since this was regarded as a grave affront to the royal majesty. These first disturbances were appeased, but on the days following they were renewed, and a number of soldiers were killed in various parts of the city.

In the presence of such difficulties, Cæsar, blocked in the port by the Etesian winds, that were unfavorable for ships that wished to depart from Alexandria, sent an order to the legions that he had organized in Asia with Pompey's soldiers to come to join him. Without waiting for them, judging that it belonged to the Roman people, and to him as Consul, to regulate the differences that had risen between the two kings, and that such arbitration was the more his duty, in that under his preceding consulship a law and a *Senatus Consultum* had ratified the alliance concluded with Ptolemy, their father, he invited young King Ptolemy and his sister Cleopatra to disband their armies and submit their quarrel to him instead of settling it by force of arms. . . . The eunuch Pothinus, governor of the King, called the army secretly from Pelusium to Alexandria, and gave the command of it to Achillas. . . . While Cæsar was negotiating with a view to ending the quarrel of Ptolemy and his sister amicably, he was informed of the arrival of the royal army 20,000 strong. Not having sufficient strength to fight outside the walls, he held his position in the city and kept his soldiers under arms. At his instance Ptolemy dispatched Dioscorillus and Serapio to the camp of Achillas. These envoys were massacred. Cæsar made sure of the person of the young King. . . .

Achillas, full of confidence in his army, and of disdain for the handful of soldiers that surrounded Cæsar, seized the city of Alexandria with the exception of the portion defended by the troops of the Consul, and even made an attempt to capture the house in which the latter lived; but Cæsar, having distributed his cohorts in the streets, warded off his attacks. At the same time, fighting was going on in the port, and this rendered the contest more difficult and bloody, for our troops had to face both the enemies who were endeavoring to force the passes and those in large numbers who were trying to seize on the galleys. Among these latter there were 50 that had been sent to Pompey as auxiliaries, and which after the battle of Pharsalia had returned to Egypt. There were triremes and penteconters, completely equipped and ready to take to the ocean. Besides this, there were in port 22 galleys of the ordinary station of Alexandria, all having an upper deck. If the enemy had succeeded in their design, they would have captured Cæsar's fleet, and remained masters of the sea and port, and the Roman army would have been able to receive neither re-enforcements nor provisions; so the contest was waged with that ardor that might have been expected from adversaries who were fighting on the one side for a decisive victory and on the other for their safety.

* In *La Nature*.

Finally, Cæsar got the upper hand, and, knowing that he could not defend himself at so many points with so reduced forces, he at once burned all his galleys, even those that were in the arsenal, while at the same time he sent a detachment to seize the Pharos. This latter is a very high tower, of wonderful construction, built upon the island whose name it bears. This island, which lies opposite Alexandria, shelters the latter's roadstead. Jetties 4,300 feet in length having been constructed in the sea by the old kings of the country, the island of Pharos is connected with the city by a narrow causeway and a bridge. It is inhabited by Egyptians, whose houses form a village which is as large as many strong cities. These people are thieves who plunder such vessels as tempests or bad maneuvering cause to miss anchorage. The pass of Pharos is so narrow that it cannot be crossed in opposition to those who hold the tower. It was for this reason that Cæsar, while fighting was still going on at other points, sent soldiers to seize the tower, and that he put a garrison into it. After this it was possible for him to receive by sea the re-enforcements and provisions which he requested from the neighboring countries. In other parts of the city the fighting was proceeding without decisive results, without extending, and without much loss. Each side kept its position. Cæsar, master of the most important points, fortified these during the night.

In this quarter was a small part of the king's palace, where Cæsar was lodged upon his first arrival; and, adjoining thereto, a theater that served instead of a citadel, and that had a communication with the port and the other arsenals. These works he afterward increased that they might serve instead of a rampart, to prevent his being obliged to fight against his will. Meantime, Ptolemy's youngest daughter, hoping the throne would be vacant, fled from the palace to Achillas, and joined with him in the prosecution of the war. But they soon disagreed about the command, which increased the largesses to the soldiers, each party endeavoring to win over the latter by large presents. During these transactions, Pothinus, Ptolemy's governor and regent of the kingdom, being discovered in clandestine correspondence with Achillas, whom he encouraged to the rigorous prosecution of his enterprise, Cæsar ordered him to be put to death. Such was the beginning of the Alexandrian war.

The war thus beginning at Alexandria, Cæsar sent to Rhodes, Syria, and Cilicia for his fleet, to Crete for archers, and to Malchus, King of the Nabatheans, for cavalry. He also ordered all the neighboring provinces to send him military engines, corn, and forces. Meanwhile he was daily employed in constructing new works; and such parts of the town as appeared less tenable were strengthened with tortoises and mantelets. Openings were made in the walls of the occupied houses through which the battering rams might play, and whatever houses were thrown down or taken by force were brought within the intrenchments. For Alexandria is in a manner secure from fire because the inhabitants use no wood in their buildings, the houses being all vaulted, and roofed with tile or pavement. Cæsar's principal aim was to inclose with works the smallest part of the town, separated from the rest by a morass toward the south; for thus the army would lie closer together, be subject to one command, and could easily send relief to the points attacked. Above all, he by this means made sure of water and forage, as he was but ill provided with one and wholly destitute of the other. The morass, on the contrary, served to supply him with both in abundance.

On their side the Alexandrians were as active as they were decided. They had sent deputies and commissioners into all parts where the power and territories of Egypt extended, with orders to levy troops. They had accumulated vast quantities of darts and engines in the city, and had drawn together an innumerable multitude of soldiers. Yet, not content with all these preparations, they established workshops for the manufacture of arms, and enlisted all slaves that were of age, the richer citizens paying and maintaining them. The remoter parts of the line of defense were occupied by these new troops, while the veteran cohorts, exempt from all other service, were quartered in the squares and open places, in order that they might be always at hand to give relief, and march fresh and entire to the charge. In all the streets and passes the Egyptians had built triple walls of dressed stone to a height of forty feet. The lower parts of the city were defended by very high towers of ten stories. Besides this, they had constructed other similar towers, that were mounted upon wheels, and movable. These latter, by means of ropes and horses, could be conveyed to any point where their service was necessary. The city, being very rich, and abounding in everything, furnished ample materials for these works; and as the people were very intelligent and ingenious, they so well copied what they saw done by us that our men seemed rather to imitate them. They even invented new things themselves, and succeeded in battering our works successfully and in defending their own. The chief citizens, in both councils and public assemblies, urged resistance.

The Roman people, said they, are gradually attempting to establish themselves in this kingdom. It is but a few years ago that Gabinus came to Egypt with an army; Pompey retired here after defeat; Cæsar has brought troops hither, and the murder of Pompey does not prevent his rival from occupying the country. If he be not forced to retire, the kingdom will become a Roman province. Moreover, haste is necessary, because Cæsar, through the approach of the inclement season, finds himself blockaded in the port with no possibility of receiving succor by sea.

As above stated, discord existed between Achillas, the head of the regular army, and Arsinoe, Ptolemy's second daughter. Each desired to obtain the power, and each was setting traps for the other. Arsinoe got ahead of Achillas, and had him assassinated by the eunuch Ganymede, her governor. Finding herself then invested with authority, alone and without control, she confided the command of the army to Ganymede, who at once assumed direction, increased the pay of the troops, and actively pushed forward the military preparations.

Almost the whole of Alexandria is supplied by a network of subterranean channels that lead the water of the Nile into cisterns in the houses. This water upon standing for a time clarifies itself. The owners and their servants made use of this cistern water, because that which came direct from the river was turbid, slimy, and unwholesome. As for the people, they were obliged to put up with the latter because there was not a single fountain in the entire city. Now, as the Nile traversed that part of the city which the Alexandrians occupied, Ganymede conceived the idea of shutting off the water from our soldiers, who, distributed over the line of defense, obtained their water from the cisterns and wells of the houses in the vicinity of their posts.

This idea being accepted, he undertook a difficult and laborious operation. Having isolated the cisterns and conduits of that part of the city of which he was master, he had wheels and machines constructed which poured a continuous stream of sea water into the canals that led to that part of the city that Cæsar occupied. The result was that the water taken from the houses nearest the enemy's lines gradually became salt, and the soldiers, not knowing how such an effect could be produced, were much astonished. Their surprise was so much the greater in that their comrades who were quartered in the more distant and lower parts of the city had perceived no change. This became a subject of frequent colloquies and comparisons between them, that very quickly proved the difference in the quality of the water. In a few days, the water of the low quarters began to get salty, and that of the quarters nearest the intrenchments became absolutely undrinkable. Then there was no longer any doubt. The terror was so great that all believed themselves to be in imminent danger. Some said that Cæsar was about to embark *instanter;* others had no faith in this resource, because they well perceived that it was impossible at so short a distance to hide preparations for a flight from the Alexandrians, and that, with the enemy in the rear, they would not succeed in embarking. Moreover, in the part of the city occupied by the Romans, there was still a large number of inhabitants that had not been driven from their dwellings, because they had pretended to be on our side. Now, I shall waste no time in divesting the Alexandrians of the reproach of versatility and knavery; he who frequents them soon learns their character, and knows that there are no men more inclined to be treasonable.

Cæsar stimulated the courage of his men, and proved to them that their fears were groundless. "Is it not evident," said he, "that we shall find water by digging wells? Are there no veins of fresh water on all these shores? What if the Egyptian coast does differ in this respect from all others? Since the sea is free, and the enemy has no fleet, what is to prevent us from going for water every day, either to the left, to Paremonium, or to the right, to the island of Pharos, points that are always accessible, whatever be the wind's direction? As for leaving, no one ought to think of that—neither those who desire to obey but the voice of honor, nor those who think only of their safety." He told them that behind their works they were repulsing the attacks of the enemy with great difficulty; that if they abandoned them, they would have the double disadvantage of position and numbers; that to reach the ships, especially by row boats, would be long and difficult; that the agile Alexandrians, knowing the localities and emboldened by their weakening, would outflank them, and seize on the edifices and commanding points; and that it would no longer be possible to get out of the city or reach the vessels. "Forget these disastrous projects, then," said he, "and be persuaded that you should seek salvation only in victory."

Having thus addressed his men and raised their courage, Cæsar ordered the centurions to drop everything else, and to work night and day in digging wells. Each one having gone to work in earnest, a large quantity of water was found in a single night, so that the labor of a few hours rendered useless the work and machines of the Alexandrians. Two days afterward, the 37th legion, which was composed of the soldiers of Pompey's army, whom Domitius Calvinus had shipped with arms, darts, and ballistæ, touched Africa a little above and to the west of Alexandria. As an easterly wind had been blowing uninterruptedly for several days, the ships had not been able to reach the port. Since the anchorage was everywhere excellent, anchors were cast, and, water failing as a consequence of the delay, a boat was sent to notify Cæsar of the arrival.

The Consul, desiring to see for himself what was best to be done, went aboard his galley, and had his entire fleet follow him. As he was to be absent some time, and did not wish to weaken his lines, he left all his soldiers on land. Having approached a point of the coast called Chersonesus, he landed his rowers in order to take in water. Some of these sailors having strayed off for the purpose of pillaging were captured by a party of cavalry, and from them the enemy learned that Cæsar was on the fleet in person, and that the vessels were not garrisoned. The occasion appeared to them decisive. They put combatants aboard all the galleys that were ready for sailing, and went forth to meet Cæsar, who was returning to the port with his fleet. The Consul wished to avoid battle on this day for two reasons, viz., first, because all his soldiers were on land, and second, because it was past the tenth hour, and darkness would necessarily prove advantageous to his adversaries, who were familiar with the place. Finally, his voice and presence would be without effect upon his men. For how, in fact, could men be stimulated whose valor or irresolution could not be known? For these reasons Cæsar approached the coast as closely as possible, thinking that the enemy would not come to seek him there.

A Rhodian galley on our right wing, having lost its station, was situated at a great distance from the rest of the fleet. The enemy having perceived it, bore down upon it with four cataphracts and several open galleys. While recognizing that a misfortune was but a just punishment for the fault committed, Cæsar, that he might not have the mortification of seeing this galley captured before his eyes, felt obliged to lend it aid. The Rhodians engaged with great vim. Always foremost as regards skill and courage, they wished, in supporting the entire weight of the combat, to repair the error committed by one of their own party. So the issue of the affair was very fortunate. One galley was taken, two were sunk, and two others lost their marines. If night had not put an end to the combat, the entire fleet would have fallen into Cæsar's hands. The Alexandrians were weakened by this reverse, and the adverse wind having lost its force, Cæsar led to Alexandria the loaded vessels towed by his victorious galleys.

The Alexandrians were so much the more astonished at their defeat in that this time they had to attribute it, not to the courage of soldiers, but to the skill of sailors. So they hauled their remaining vessels further toward the shore, in order that they might be defended from the housetops; and in order to ward off an attack by our fleet from the side toward the coast, they accumulated obstacles of all sorts along the shore. Meanwhile, Ganymede having pledged himself in a council to replace the vessels that had been lost, and even to increase the number of them, these same men, with confidence restored, began to repair their old galleys with the greatest ardor. Although, in the port and arsenal, they had lost more than one hundred and ten, they undertook to rebuild their fleet. They perceived, in fact, that if they were the stronger on the ocean, Cæsar would be able to receive neither provisions nor aid. Moreover, a people that inhabited a maritime country and city, devoted to navigation and familiar from childhood with its risks, and emboldened by the success that it had gained with its little barks, was, by instinct, forced to be proud of an element that it believed inherent to it. So it directed all its efforts toward the equipment of its fleet.

At all the mouths of the Nile there were stationed ships for collecting entrance fees, and in the rear of the royal arsenal there were some old galleys that had long been dismantled. The first of these were ordered to Alexandria, and the second were repaired. As oars were needed, porticoes, gymnasia, and other public edifices were opened, and the rafters used in their manufacture. The resources of the city and the skill of the inhabitants sufficed for everything. At the most, it was not for the needs of a long navigation, but merely for the exigencies of the moment, that it was necessary to provide, and they well knew that it was in the port itself that it would be necessary to fight. Thus it was that, in a few days, and contrary to all likelihood, they equipped 22 tetraremes, 5 pentaremes, and a goodly number of galleys of lower rank. After trying their anchors in the port, and organizing their rowing, they took picked soldiers aboard and completed their preparations. Cæsar had 9 Rhodian galleys (for of the ten that had been sent him one was lost on the coast of Egypt), 8 from Pontus, 5 from Lycia, and 12 from Asia. Among these there were 5 pentaremes and 10 tetraremes. The others were of smaller dimensions, and most of them were open. Despite the inferiority of his forces, Cæsar, confiding in the valor of his soldiers, prepared for combat.

The preparations having terminated on both sides, and each counting upon a victory, Cæsar took a turn around the island of Pharos, and moved toward the enemy. On his right wing he arranged the galleys from Rhodes, and on his left those from Pontus. The two groups were formed at about 600 yards from each other—a space that appeared sufficient to him in which to display the line of battle. Behind these two columns the other galleys formed a reserve. Each captain knew which ship he must follow and lend aid to. The Alexandrians unhesitatingly got under way, and put themselves into battle array. Their front line was composed of 22 galleys, while the rest were in the second line as a reserve. Along with their galleys there sailed a large number of small ships and boats carying incendiary engines. The Alexandrians hoped that their numbers, the shouting of their crews, and the sight of flames would frighten our forces. The two fleets were separated by a line of high lands, intersected by narrow passages, and extending as far as to the coast of Africa. (According to the inhabitants, the territory of Alexandria is partly Asiatic and partly African.) Each side hesitated for quite a long time to cross the passes, because it was well known that the one that decided to do so would be in a disadvantageous position, both for deploying in order to attack and for retiring if it got worsted.

Euphranor, who was in command of the Rhodian galleys, was a Greek with the courage and the grandeur of soul of a Roman. His fellow citizens had selected him for his ability and valor. Seeing the indecision of the Consul, he said to him: "Cæsar! thou appearest to fear lest the ships that first enter these passes be forced to fight before the rest of the fleet can deploy; permit us the honor of running such risk. We will take the brunt of the enemy's attack, and show ourselves worthy of thy confidence, until the rest have put themselves into line. As for those people over yonder, it would be with sorrow and shame that we should see them longer brave us." Cæsar, after encouraging and eulogizing the valiant Euphranor, gave the signal for combat. Four Rhodian galleys traversed the pass. Surrounded and charged upon by the Alexandrians, they sustained the attack, and, by a skillful maneuver, succeeded in deploying. Their rowers were so well drilled and commanded that, despite inferiority in number, none of the vessels got crosswise, none lost its oars, and that they always presented their rostra to the enemy's ships. During this time the rest of the fleet entered the large port. Then the space became too narrow to permit of further maneuvers, and it was now no longer skill, but courage, upon which the issue of the fight was to depend. At this moment there was not a single man in the city, either of our own or of the Alexandrians, that did not forget the siege operations and ascend the highest terraces in order to witness the battle; and every one was making supplications to the immortal gods, and asking them to allow his side to triumph.

The price of victory was not the same on both sides. If conquered, ours would have refuge neither upon land nor sea; if victorious, it had still to conquer. If the fleet of the Alexandrians gained the upper hand, we were at their mercy; if it were worsted, all chance of final success was not lost. It was a sad and hard experience to see a handful of men fighting for the honor of our arms and the common safety. It was not only for himself that each one had to display courage and energy, but it was for companions who could not fight alongside of us. This is what Cæsar on the preceding days had very often repeated to his soldiers—exalting their courage by the conviction that the salvation of all was to depend upon their efforts. After his example, each one had begged his neighbor, his comrade, not to deceive the expectations of those who had selected them as the most worthy of taking part in the combat. So our side fought with such fury that

neither the skill of their marines nor the superior number of their vessels was of any avail to the Alexandrians, and that the picked men of their combatants, selected from an immense number of soldiers, were unable to dispute victory with ours.

The rest of the Alexandrian fleet fled toward the city, which was at a short distance, and there it was protected by soldiers, who, standing upon the moles and upon the edifices that overlooked the coast, prevented our galleys from approaching. Not wishing to be forced to give battle again under the same circumstances, Cæsar resolved to make every effort to seize the island and the jetty that connects it with the continent. As his works toward Alexandria were about finished, he judged that he might be able to attack both the island and the city. Having resolved on this, he embarked ten cohorts, the elite of his light infantry, and those of the Gaulish cavalry that he deemed best fitted for this expedition, in canoes and small ships. At the same time, in order to divide the enemy's forces, he sent some cataphracts to attack the external side of the island, promising large rewards to those that should first seize it. The Pharites at first did well, fighting both upon the terraces of the houses and the elevated points of a coast difficult to scale. Five galleys and a few boats maneuvered with skill aided in the defense. But when, after the places had been reconnoitered, and the passes sounded, some of our men had landed, others followed, and altogether they made a charge upon those who occupied the top of the cliff. Then the Pharites turned their backs, abandoned the post, and fled toward the village; and those who manned the vessels abandoned them in order to defend their houses.

Notwithstanding that these latter, which were on a small scale, were like those of Alexandria, and that a line of connected towers between them constituted a true wall, and that our soldiers had no ladders or hurdles or anything necessary for an assault, the Pharites were unable to hold out long in their new position. Fear, as was then to be seen, leaves man without judgment or strength. Those very ones who had hoped to resist us upon level ground and with equal arms, struck with terror by the rout of their fellows and the death of a few, dared not await us behind walls 30 feet in height, but threw themselves into the sea from the top of the jetty, and by swimming reached the city, which was 800 feet distant. A large number of the inhabitants of the island were killed or captured. The number of prisoners was 600.

Cæsar having given the soldiers permission to pillage, gave orders to fell the houses near the jetty, and, with the materials, to fortify the tower that commanded the bridge nearest the Pharos; and then he put a garrison into it. The Pharites, in their flight, had abandoned this bridge and its defenses, but the other bridge, nearer the city, was still in the hands of the Alexandrians.

On the next day Cæsar, pursuing the execution of his plan, endeavored to seize this, well knowing that once master of the two passages, he could prevent the running of boats from one port to the other and the depredations of those who manned them. With their bows and ballistæ, the crews of the Roman galleys had already driven the defenders from the bridge, and had forced them to re-enter the city. Cæsar then landed about five cohorts (as a larger number of soldiers would not have been able to maneuver on so limited an area), while other troops held themselves in readiness aboard the vessels. These arrangements made, he ordered an approach to be constructed on the enemy's side, and the arched space under which vessels passed to be filled in with stones. This latter work was already so far advanced that no boat, however small it might be, could pass from one port to the other. The other was in course of execution, when the Alexandrians, with all their troops, made a sortie from the city, and spread themselves out in front of our intrenchments. They at the same time sent their barks along the jetty, by passing under the bridges, in order to set fire to our ships. Our men were fighting to defend the bridge and causeway. The enemy attacked them from the terrace that touched the bridge approach and from the ships that had come up alongside of the jetty.

While Cæsar was wholly devoting himself to encouraging his soldiers in this double contest, a large number of our oarsmen and sailors jumped from the galleys to the jetty. Some were urged by curiosity and others by a desire to fight. At first they began to drive the enemy's vessels from the jetty with stones and slings, and the arrows that they shot in large numbers seemed to be producing considerable effect. But when, off the point where they were fighting, a few Alexandrians dared to disembark and flank them, these men, who were not organized and who had engaged without reason, and had no ensigns, took refuge on board their galleys with imprudent haste. The emboldened Alexandrians disembarked in greater numbers, and pursued the fugitives with ardor. Then those who had remained on board hastened to remove the ladders and shove the vessels off in order to prevent them from falling into the enemy's hands. The soldiers of the three cohorts that Cæsar had ordered to occupy the bridge and the head of the jetty, hearing cries in their rear, seeing their comrades in flight, and having to sustain a very sharp attack in front, feared that they would be flanked and be unable to regain the vessels that seemed desirous of getting to a distance.

Seized with terror, they abandoned the works begun and ran to the vessels. One portion of the legion jumped into the nearest galleys, which sank under their weight. A certain portion, not knowing what to do, and offering resistance, were massacred by the Alexandrians. A few, who were more fortunate, reached the galleys more distant from the shore safe and sound. Others, throwing away their bucklers, and risking everything for safety, reached the most distant boats by swimming. Cæsar, using every effort up to the last to hold back his men to defend the bridge and works, ran the same dangers. When he saw that the legionaries were giving way, he entered his galley. A host of men followed him into it, and, as there was no way either of assigning them posts or of pushing the vessel off, he foresaw what was going to happen, jumped into the sea, and by swimming reached the galleys that were riding at anchor at a distance from the causeway. From thence he sent out boats which managed to save a few of his men. As for his own galley, that sank under the weight of the soldiers who had boarded it. In this fight the Romans lost 400 legionaries and a little more than 400 oarsmen and sailors. On the place that we had just abandoned the Alexandrians performed much work in order to complete the defense of the existing tower, which they provided with numerous ballistæ. They cleared out the passage that we had filled up, and were thereafter able to use it for passing their boats through. This check did not discourage our soldiers, but made them the more ardent in their attack of the enemy's positions. . . .

From this time on, the operations that led to the taking of Alexandria and the conquest of Egypt are easy to follow. From the special point of view that occupies us they present no further interest.

The narrative just given is so precise that the competence of the writer cannot be discussed. If these pages are not from the hand of Cæsar, they have passed under his eyes. It is, then, a historic document of incontestable authority. For the general history of the navy, we can draw from it the following important deductions:

1. If we admit, empirically, that half of Cæsar's cavalry, at the moment of its arrival, with corps reduced to a third of their effective strength, were mounted, and that his transport fleet consisted of 16 galleys (10 from Rhodes and a few from Asia), we reach a quotient of 250 men and 25 horses per galley. This is what the pentaremes covered with a catastroma (as described by Polybius) were capable of carrying on a short voyage.

2. The 50 triremes and pentaremes sent to Pompey's aid, and that returned after the battle of Pharsalia, composed two-thirds of the disposable Egyptian fleet. Supposing the number of triremes equal to that of the pentaremes, their effective force as a whole did not exceed from 15,000 to 20,000 men.

3. When the Alexandrians reconstructed their fleet by arming the old ships taken from their arsenals, they did not find a single one of those galleys of superior rank that we have seen figuring at the battle of Chio, and less still any polyreme comparable with those of the 10, 20, or 30 ranks of rowers that Athenæus mentions in enumerating the fleet of Ptolemy Philadelphus. It results from this that in the time of Cæsar the navy called by historians the "Navy of the Ptolemies" had disappeared, and it is improbable, not to say impossible, that the Egyptian navy, completely destroyed during the siege of Alexandria, was represented a few years later, at the battle of Actium, by gigantic types that had so long been forgotten.

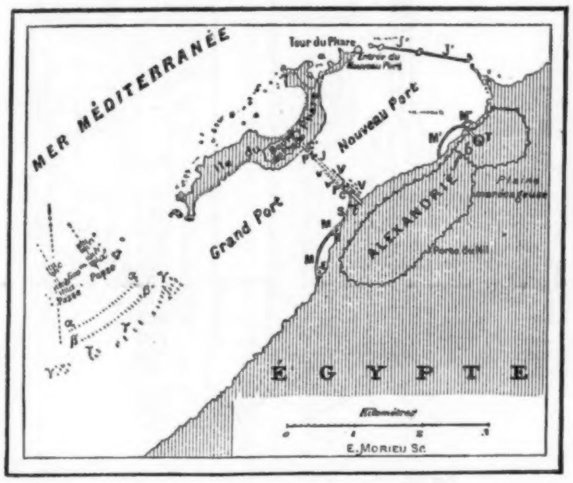


FIG. 1.—PLAN OF THE SIEGE OF ALEXANDRIA BY CÆSAR.

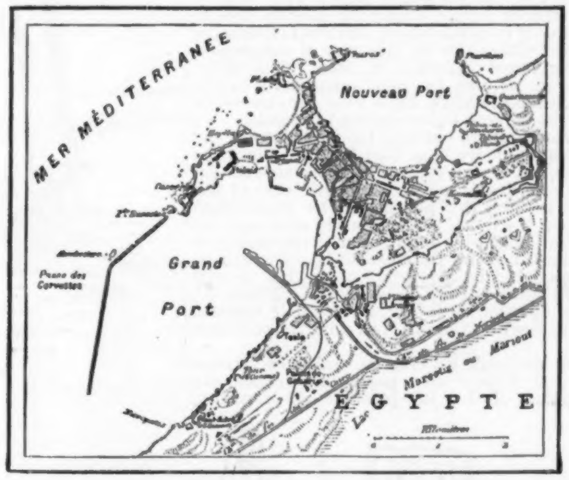


FIG. 2.—PRESENT STATE OF THE CITY AND PORTS OF ALEXANDRIA; SHOWING THE GEOLOGICAL AND GEOGRAPHICAL CHANGES SINCE CÆSAR'S TIME.

ACCORDING to the *Chinese Recorder*, Dr. Wallace Taylor, a missionary doctor of Osaka, Japan, has made important discoveries regarding the origin of the disease *kakke*, or *beriberi*, as it is known in Ceylon. He traces it to a microscopic spore, which is often found largely developed in rice, and which he has finally detected in the earth of certain alluvial and damp localities.

SUPERSEDING THE HORSE.

WHAT sort of propelling power is to supersede the horse as a motor for city passenger railways continues to be an anxious question among the active managers and owners of the companies devoted to that kind of transit. It is an important question to both them and the public, for there seems to be an understanding that the horse must go—out of service as too expensive a motor for the large number of cars required at some few hours of the day. The latest expert and professional inquiry into the subject comes from a distant city, and of all cities it is from San Francisco, where it was supposed that the success of the "cable" system on several lines had settled the question. But it seems to be conclusively settled there only for such lines as have heavy grades, as to which it is admirably adapted, and considered to possess great superiority over horse power, and perhaps over any other known system. On one such line there (Sutter street) it is on record as having been definitely ascertained as far back as 1878, as between the horse-power system and the cable system, that the economical advantage in favor of the cable was a saving of thirty per cent. in running expenses.

Still it is from that city that we have the official report of an inquiry upon the subject. A company there with a roadway four and a half miles long, the course and grades of which are level or nearly so, which has been operated successfully for some years by horse power, requested its consulting engineer (Mr. W. H. Milliken) to inquire into and report upon some practical mode of propulsion other than horse power, with the view of improving its service and producing more economical results. He seems to have gone into the matter with considerable thoroughness, taking up the practicable substitutes for horse power, viz., ordinary steam engines, coal-gas engines, electrical engines, compressed-air engines and cable traction. Each of these is taken up in turn, and the compressed-air motor is considered in its two forms of very "high pressure" and "low pressure." The steam engine, that is, an engine for every separate car as distinct from an engine for a "train" of cars, is set aside as being too bulky and heavy for the ordinary street railway bed; as being too expensive, because so much of its power is used in hauling its own weight and its fuel and water; as requiring a skilled engineer; as being uncleanly, dangerous, and offensive. Some of these are, notwithstanding, in use in several cities.

The coal-gas motor is objected to upon the allegation that it is not readily manageable as to stopping and starting; that it has to be kept running whether it is hauling the car or not; that if the charge in the gas holders carried by the car should happen to be exhausted on the trip, it would be helpless, having no recuperative power in itself, and would be expensive to construct, operate, and maintain. This is said in full view of the fact that an experimental car of this kind driven by a 3¼ horse power gas engine, and carrying twenty passengers, making the total burden four tons, recently made a round trip run, near Sydney, Australia, of four and two-third miles in thirty-one minutes, which is at least two miles an hour faster than the speed allowed street cars in cities. The pressure of the gas in the cylinders was 66 pounds at the start and 32 pounds at the end of the run. The gas consumed was nine cubic feet per mile.

As to electricity, it is said in the report that no electric system has yet been practically developed which promises cheapness of construction. The use of an overhead conductor involves too many difficulties; the "storage battery" system is held to be inadequate; the only promising projects being conductors laid under ground or (in the case of elevated roads) on the surface. And as to the underground conductor, it is objected that the plant for the purpose would be nearly as expensive as for a cable; that the amount of useful effect that can be obtained from electricity for railway purposes is yet unknown; and that the necessary gearing on the car to reduce the speed of the dynamo to the speed of the car wheel would be far too noisy, as was found in the Cleveland (Ohio) experiment.

The air-pressure system is next considered, first, as to the high pressure engines. The engine for this system is represented as very heavy (eight to ten tons), too heavy for the ordinary street track; the compressed air is stored at an initial pressure of 450 pounds, yet has to be worked at a much lower pressure, say 100; the machine is too bulky for street traffic, too costly at the outset and too expensive to operate and maintain; and like the gas engine it has no recuperative power in itself if its store of compressed air gives out.

The field of inquiry is thus cleared of all plans except the "cable" and the "low-pressure compressed-

air system." As to the former, it has the advantage of eight or ten years of experience in San Francisco, and three or four years in Chicago. It is coming to the notice of Philadelphians in the tunnels and cables being laid down and partly in use by the "Traction Company" of the Union Line; and they are learning something of the botherations of introducing the system, though this has happily been unattended here thus far by any such loss of life or serious injury as happened in Chicago. For the "cable" system, besides the advantages already mentioned, and the facility with which any number of cars can be added during the hours when travel is largest, it is favored as having largely decreased running expenses, as compared with horse power, and is more profitable to operate; it is preferred by the traveling public in the cities where it is used, it is more satisfactory to residents along the line, and the running expenses are much less subject to fluctuation than horse power. There are drawbacks to all this, however. The plant is expensive at the outset; there is risk that the whole line may be disabled by breakage; the cable has to move at the same expenditure of power, whether there are many cars and passengers or few; a large proportion of the power used (estimated at 68 per cent.) goes to the moving of the cable itself, and there is serious difficulty if there are frequent turns and curves. On the whole, however, the cable is set down as superior to horse power and any other system yet put into practice.

The "low-pressure compressed-air system" is the last one considered in Mr. Milliken's report. He favors it over all others for the particular line in San Francisco in whose behalf he made the inquiry. That, as we have said, was a level stretch of four and a half miles with a branch one mile and a quarter long. According to the "low-pressure" plan, the car is to contain, under the benches or overhead, air receivers capable of carrying fifty cubic feet at a pressure of 100 pounds to the inch. This compressed air does the work of driving the engine, instead of steam or gas or electricity. To guard against the accident of the stock of compressed air-power giving out somewhere along the line, and thus leaving the car and its passengers helplessly stuck, a pipe is laid the whole length of the track, conveying compressed air from the station receivers, and by a simple but ingenious contrivance of outlet valves at average distances of 500 feet apart, this pipe can be tapped for a new supply of power by the car conductor or engine driver in case he should need such help. If it works fairly, this would overcome two of the great difficulties in the way of compressed air-engines for street railways in cities. The outlet valves, however, require frequent open holes in the street, which, though only a little over two inches in diameter, might be very objectionable in practice.

Several advantages are claimed for this system: the plant is far less expensive than that for the cable or the electric engine, the steam, gas, or high-pressure air engine; the air pressure is only one-fourth that of the high-pressure motors; the power can be replenished anywhere along the line if it happens to give out; the engines are light; the plan requires but little change in the form of the car or in the road-bed, and it can be put into operation without interfering with present traffic, though this has been done by our "Traction" and allied companies in laying down their tunnels, cables, etc., on Market, Columbia avenue, Seventh and Ninth streets.

While every mechanic who has general knowledge of such devices and of the science pertaining to them can form a judgment of this low-pressure air-propelling power from the reference we have made to it, we must say that Mr. Millikin, the San Francisco engineer who makes the report, recommending it in earnest terms to his company, seems to have an undue bias in its favor, considering that it has never been tried, except in an experimental way, in an iron works in that city. But, then, as an offset to this, it is to be said that the proprietors of those works (the Risdon Iron Works) offer, under reasonable conditions, to construct a line at their own risk for any company desiring it.—*Phila. Ledger.*

ARTESIAN WELLS.

NOTES ON DRILLING AND BORING ARTESIAN WELLS, AS PRACTICED IN THE UNITED STATES OF AMERICA.

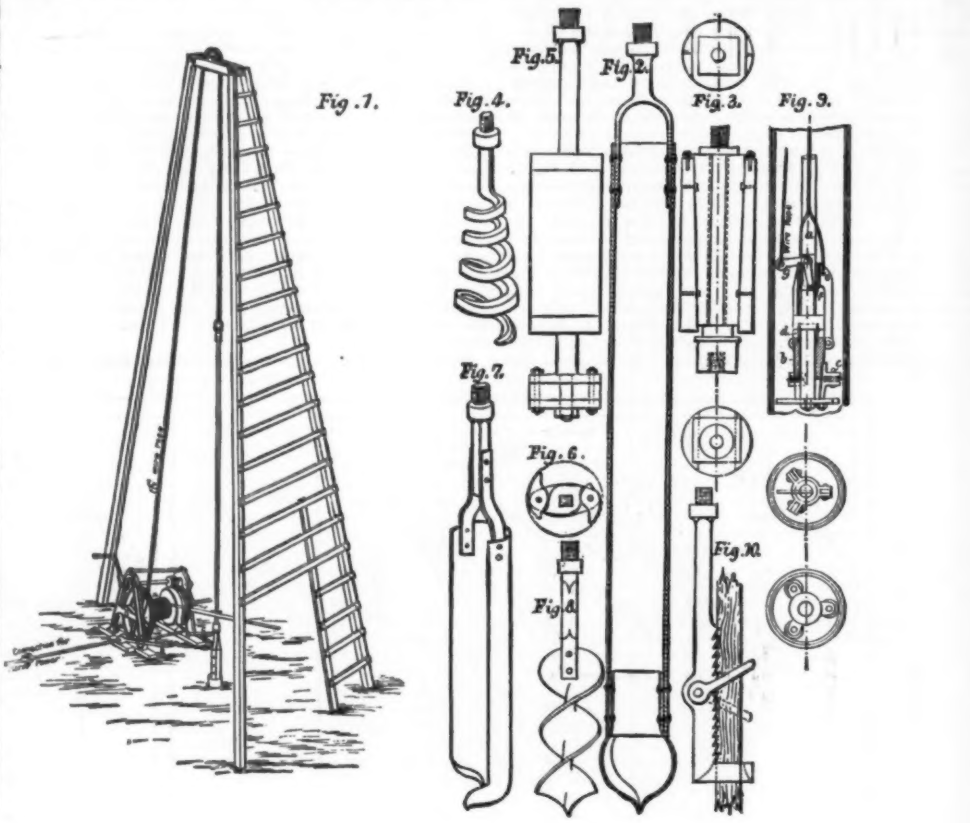
By C. W. DARLEY.

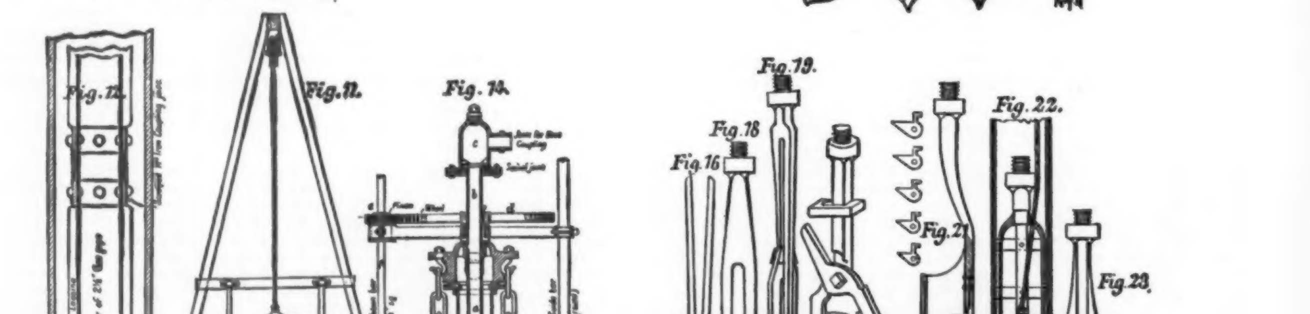
DURING my recent visit to America I availed myself of the opportunity thus afforded of inspecting the various systems which have been adopted there for sinking artesian well bores, and, at the request of the honorable the Colonial Secretary, I now have the honor to submit a report upon what I saw, together with particulars and sketches of the appliances in use. I trust that my notes may be of some practical benefit and assistance to those who are likely to be engaged in searching for water at great depths in these colonies.

In some respects I fear the information I have obtained may appear scant and insufficient, but it must be borne in mind that the time at my disposal was somewhat limited, and the distances to be traveled over, in order to see the various boring operations in progress, were immense.

The boring, as hereinafter described, being in most cases carried on by contractors who have portions of their apparatus covered by patents, some difficulty was found in obtaining information on many important points of practical detail, the contractors frequently being reticent, and suspicious as to the object of my interrogations; on the other hand, manufacturers and vendors of apparatus were most willing to furnish me with abundant information, but in all cases this had to be received *cum grano salis*, as the information supplied seldom went beyond praise of their particular apparatus, and but rarely were any really useful and practical notes to be obtained from such sources.

The States where I found most boring operations in





APPLIANCES FOR BORING ARTESIAN WELLS.

progress were California (where wells are being sunk for both water and oil), Colorado, New York, and Pennsylvania; in the latter State, so far as I am aware, oil and gas wells only have been sunk.

The process of sinking holes through rock, as is necessary in nearly all instances where great depths have to be reached, either for water or oil, is usually termed "drilling," and "boring" where alluvium or gravel and sandbeds only have to be passed through; but in these latter cases drill gear is sometimes used to advantage, as will be hereinafter explained, the immediate difference between the two methods being that drilling is usually done with only a limited length (about 40 feet) of iron rods, which are worked suspended from a stout hawser, while boring is carried on with continuous bars, either wood or iron, in about 25 foot lengths.

In California, I found a great number of wells being bored all through the San Joaquin Valley, which embraces a large district, some 280 miles in length north and south, and some 70 or 80 miles wide, lying south of Stockton and between the foot of the Sierra Nevada on the east and the Coast Range on the west.

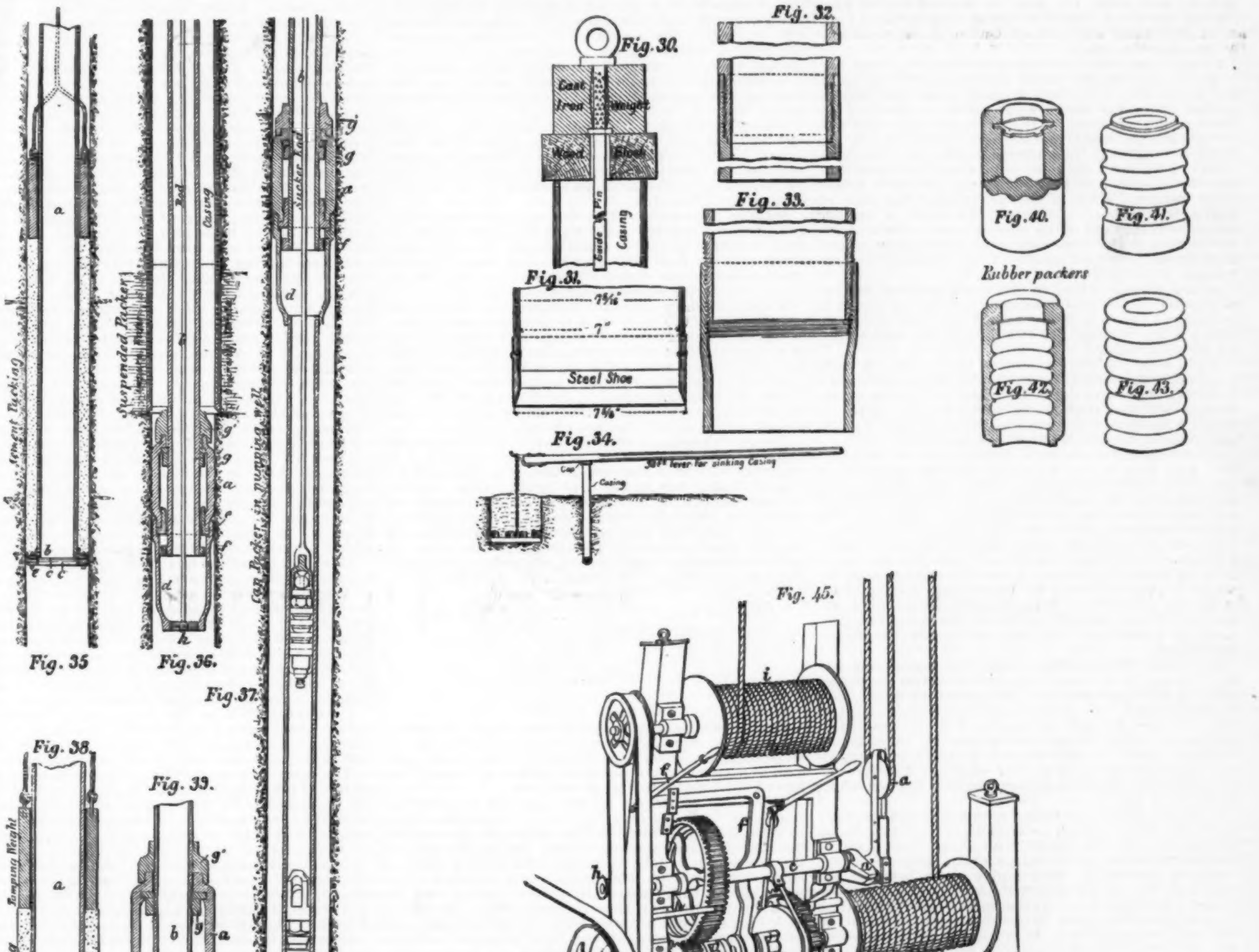
ground was found strong enough to stand without casing, unlined bores were tried, but they were found never to flow till lined.

The absence of water-tight lining will probably be found the reason why water has not risen to the surface more frequently than it has done in the numerous well shafts sunk in Australia, where it is well known that a porous stratum, frequently containing brackish water, is usually found at depths of from 40 ft. to 90 ft. below the surface, the brackish water in some cases having been stopped back sufficiently to allow the sinking to continue till fresh water was reached; the latter then rose in the well to within some 30 ft. to 60 ft. of the surface, but no higher. There can be little doubt that in such cases the lower water found an escape through the pervious measures; had a water-tight lining been used, it is quite possible that many of these wells would now have been flowing ones, *i. e.*, the water would have risen above the surface.

I wish, however, to guard myself from being misunderstood on this point, as I do not desire to raise false hopes by conveying the idea that any method of treating artesian bores in water-bearing measures will

1. The ordinary boring apparatus, with a variety of special tools used in connection therewith.
2. The hydraulic well borer.
3. The ordinary drilling apparatus, as specially suited for artesian wells where the depth rarely has to exceed 600 ft.

Hand-Boring Apparatus.—The ordinary boring apparatus consists of a wood or iron derrick with a sheave on top, about 30 ft. over the ground; beside a single leg is placed a crab-winch carrying a sufficient length of 1¼ in. iron or steel wire rope; the winch usually has two driving pinions, one for working by hand, the second for working by horse-gear, for running up the rope quickly, more especially when working with the sand pumps. The boring bit (varieties of which are shown on Figs. 7, 8, and 24 to 29) is attached to the rods, which are usually made up in 25 ft. lengths, either wood or iron, the iron ones being made of 1½ in. gas-pipe, with screwed pin and box ends welded on; these, however, would be found too heavy on the boring tool if wholly used, so it is the practice to use some rods of pine, 4 in. by 4 in., which, owing to their buoyancy in the water, with which the bore is charged,



APPLIANCES FOR BORING ARTESIAN WELLS.

The water is usually found at depths varying from 350 ft. to 600 ft. in a bed of sand, which is overlain by beds of impervious clay, and clay and gravel mixed, the upper 40 ft. to 80 ft. throughout the valley being light loamy and alluvial deposit.

In the gravel beds, immediately beneath the upper alluvial deposit, water is frequently met with, but it is usually limited in quanity, indifferent in quality, and seldom or indeed never rises to the surface; on small farms and homesteads, however, it is not despised, being generally sought for and obtained by the ordinary drive or Abyssinian tube wells; but as the water must then be pumped, it cannot be economically used for irrigation purposes, although in some districts where water has not been obtained from deep artesian wells, hundreds of the drive wells have been sunk and the water raised by windmills.

When sinking artesian wells, it is necessary to stop back this upper water, for two reasons: first, to prevent it contaminating the purer supply from below; and, secondly, which is the more important, to prevent the rising water being lost or absorbed in the upper pervious measures. This led to the bores being lined throughout with iron tubes or casings, which is an imperative necessity, for, in some instances, where the

obtain flowing wells, as this wholly depends on the situation of the bore geologically; to obtain this, the water must be stored in the earth and have communication with an under stream or water-bearing stratum, leading from hills situated higher than the ground surface at the bore. The hill source may be a great distance away; still, if the water-bearing stratum is overlain with measures of impervious clay, upon these measures being pierced the water will rise to the surface, unless, as before mentioned, it finds an escape through upper pervious measures.

In the case of the San Joaquin Valley, already referred to, the abundant supply found there of course comes from the neighboring Sierra Nevada, where the winter snow is stored, and given out throughout the spring and summer months, just when the water is most needed, the mountains thus acting as a natural reservoir for conserving the water.

So far as I could ascertain, the cost of the work is very much the same with one apparatus as with another; but as there are varying circumstances under which each kind may have a special advantage, I will describe three kinds of apparatus which will fairly represent the different types of machines mostly in use:

help to balance the weight of the iron rods. The top or working rod is usually made of 1¼ in. square iron, on which a capstan spanner travels and works; two men are sufficient for giving the necessary circular motion to the rods. It will be seen that in this process much delay must necessarily be incurred in drawing the rods every time the auger is filled, which happens about every fourth or fifth foot sunk. The rods on each such occasion have to be raised, unscrewed, and laid aside one by one, the reverse operations, when lowering, taking an equal time. Notwithstanding this delay, I found that the 7 in. wells were bored to a depth of 400 ft. and lined with casing at an average rate of nearly 25 ft. per day—the first 100 ft. being performed much quicker, and, of course, the last 100 ft. proportionately slower. When adding on or sinking casing, the rods need not be withdrawn, but left standing on the bottom or suspended from the expanding plug, the top or capstan length only being removed. The auger bits are made in a variety of patterns, some altogether with closed sides for working in sandy or very loose ground, others made with one side quite open like a carpenter's shell auger, and termed the pod auger; see Fig. 7. This pattern is found to work very well in stiff clay, and is readily emptied. When beds

of fine sand are met with, then the sand or sludge pump, as shown at Fig. 2, must be used; this is usually lowered by a small line and jumped when at bottom till the sludge or sand is worked up loose, when it readily fills, and upon being drawn up quickly the ball valve prevents the sludge from escaping; when emptied it is again lowered, and the process repeated till the bore is clear ready for the rods to be lowered and the boring resumed.

Besides the common sand pump last referred to, which can only be filled by jumping it on the bottom, there are others made with a sucker valve rod, which, when the pump reaches the bottom, is worked up and down with a light line from the surface; this pumps the barrel full of the sand or silt, at the same time discharging the water above the plunger. Another form of pump for clearing out bores is shown in Fig. 20. The great advantage attending this somewhat more expensive form of pump is the facility with which it can be emptied by simply knocking up the sliding sleeve on top, when the tube opens longitudinally with a scissors joint, instantly releasing its contents.

Care must be taken in boring not to let the excavation get too far in advance of the casing, or the sides cave in, and cause the bore to become out of line. Should this occur, it may be found impossible to force down the casing, and consequently render it necessary to abandon the bore.

I found that the invariable practice is to start the bore 7 in. in diameter, and if possible carry it the same size all the way down, but in most cases the friction against the casing becomes too great to admit of its being sunk more than 300 ft. of this size, and then a 6 in. casing is put inside and the hole carried on with the smaller diameter to the required depth. In a few cases I found 8 in. and 7 in. holes being sunk, but these sizes are exceptional, 7 in. and 6 in. being generally found large enough. When a hole containing two sizes of casing, in this way, is finished, the inner or smaller casing is usually cut off by special tools a little above the bottom of the large casing, and the upper length withdrawn to be used again. A tool suitable for this purpose is shown in Fig. 9.

As it is necessary that the auger should bore as near as possible to the inside diameter of the casing, it is necessary to have a set of augers for each size, *i. e.*, about a 6¾ in. auger for the 7 in. casing, and 5¾ in. for the 6 in. casing.

When about to start a bore, as soon as the derrick is set up, a hole should be dug under the center some 6 ft. to 8 ft. deep, and the first length of casing set up vertically in the center; the earth is then filled in round it again and well rammed, thus forming a guide and insuring a fair start for the boring tools.

A horse-power machine is usually used in conjunction with this boring apparatus, for the purpose of operating the winch rapidly when drawing the rods and working the sand pump; the most convenient method of conveying the motion to the winch is with friction wheels applied with a cam motion; in this case the horse can be kept constantly moving when drawing rods; the attendant need only place his foot on a lever to throw the friction pinion in contact with the winch wheel, and thus wind up the rods 25 ft. at a time or as may be necessary. The circular motion for working the rods is, however, given to them by two men walking round with the capstan spanner as before mentioned.

Hydraulic Boring Apparatus.—This apparatus (see Figs. 11 and 14) is worked very much on the same principle as the diamond drill, the action of which is, I believe, pretty well understood now in this country. The rods are formed in the usual 25 ft. lengths of strong gas or lap-welded iron piping, 2½ in. or 2¾ in. internal diameter, with screwed wrought-iron spigots and socket connections at their ends (see Fig. 12); the lower length carries the cutter, the best form of which is shown at Fig. 13.

A strong stream of water is pumped continuously down the rods, through a swivel cap at the top, shown at Fig. 14. The rods are driven at a speed of about 80 to 100 revolutions per minute, and the debris from the cutter is carried up the annular space between the rods and the casing with the escaping water, and discharged at the surface. As the casing is rarely less than 7 in. internal diameter, it is necessary to thicken up the rods, incasing them in wooden lagging to reduce the area between the rods and casing, and thus increase the velocity of the discharge water, to enable it to carry up the debris as fast as the cutter excavates it. The rods, joint, and lagging are shown at Fig. 12.

The arrangement of derrick used is shown in Fig. 11. To secure the proper speed and power requisite to manipulate this machinery, a steam engine is necessary. The pump for forcing the water down the boring bar may be attached to the engine, and the water supplied to the pipe head through a flexible rubber hose. This machine is capable of doing very rapid work. I witnessed about 20 ft. being sunk in about half an hour, the depth of the bore at the time being 524 ft. below the surface; this included pressing down the casing at the same time, but of course not the building and riveting up of the casing, this part of the work occupying more time than the actual boring.

The contractor had arrived on the ground with his plant to start the bore just 11¾ working days before the date of my visit, and, as above mentioned, the bore was then over 500 ft. deep, cased all the way; necessarily some time was lost at first in setting up the derrick and engine, excavating a tank for water supply, etc., so that the actual boring and casing must have been carried on at a rate considerably over 50 ft. per day. The actual quantity of water required was not very great; for by providing a settling tank to receive the discharge water, the silt and debris soon settles, and thus the same water can be used over and over again. However, the very fact of any water being required, even for working the engine, will restrict the use of this apparatus very much indeed in Australia.

Upon reference to Fig. 14, it will be observed that on the upper hollow boring bar, *a*, is screwed a short length, *b*, carrying a cast iron chamber, *c*, in the base of which the head of the short bar, *b*, can revolve freely between brass washers, at the same time making a comparatively water-tight joint; on the same bar is keyed a spurwheel, *d*, into which a pinion wheel, *e*, gears; this pinion has a square hole through the center traveling freely up and down the 1½ in. square bar, *f*, at the side; to this bar is conveyed rapid rotary motion through bevel wheels, *g*, which are driven by a belt from the main shaft, *h*. As the bars sink in the hole, the pinion slides down the square bar, following the spurwheel, and imparting the necessary rotary motion to it in every position. To the head, *c*, is coupled the flexible hose leading from the pump attached to the engine.

In this apparatus, as in the hand-boring apparatus, much time is lost when it becomes necessary to draw the rods; but of course, owing to the debris being conveyed out of the bore by the water, the rods have not to be so frequently drawn; but when a gravel bed is passed through, the large stones cannot be washed up, and the rods must then be drawn, and a large-valved sand pump lowered to bring up the shingle, etc. With this apparatus I saw hydraulic pulling jacks very suitably applied for drawing down the casing, which will be described further on, one man attending them drawing down the casing, while the second man attended to the engines and boring apparatus. An ingenious and simple device for suspending the rods in the bore while adding on casings is shown in Fig. 3. This is simply a round piece of pine, nearly the diameter of the casing, cut in three pieces, the central portion being wedge-shaped. Into this piece is fixed a length of bar with spigot and socket screwed unions; this is screwed on to the top of the rods, and lowered; when a short way down, the side pieces are checked with a string; the weight of the rods drawing down the central wedge causes the blocks to jam in the casing; there they remain suspended till the upper bar is lowered down, screwed on, and pulled up, thus drawing the wedge, and permitting the rods to run up freely.

It is only right that I should mention that Messrs. Jerome Haas and James Manning, of Stockton, California, U. S. A., contractors for well-sinking, have brought this system to great perfection, and have taken out several patents for improvements in the various parts of the apparatus.

Drilling Apparatus.—The drilling apparatus ordinarily used for sinking wells not exceeding (say) 800 ft. deep is both handy and portable, and is usually provided with an axle and wheels, which enable it to be transported across country easily, all the gear, horse-power, etc., being stored on top for transit.

When holes have to be sunk much greater depths, such as 1,500 ft., to 2,000 ft., then it is desirable to use much heavier appliances driven by steam, and what is known as a walking beam or Pennsylvanian rig becomes necessary; this is, however, seldom made in a portable form, a fresh derrick being usually erected over each hole. Nearly all drilling apparatus, for bores from 600 ft. to 800 ft. deep, are worked on the same principle, so one description practically answers for all.

The derrick has two working barrels; on one is wound sufficient 2 in. rope, termed "the sand pump line," to reach the bottom of the deepest bore required, and the second barrel carries the drill cable, which may be either a hempen or Manila rope of similar length and about 5 in. girth; this rope passes from the barrel over a sheave, fixed half way up the derrick, then down and through what is termed the pitman sheave, then up and over the sheave at the head of derrick, and finally down and made fast to the head of the drill bars.

The drill bars are made up as follows:

First the bit....................	about	4	ft. long.
Next the auger stem	"	12	"
" the jars	"	5	"
" the sinker bar............	"	8	"
" the rope socket..........	"	1	"
In all say...		30	"

The above lengths may vary very much, of course, according to circumstances, the bars used for deep oil wells being made up as much as 60 ft. long and up to 4 in. in diameter; those used for shallow holes need not exceed from 2⅛ in. to 3 in. in diameter.

The derrick is first set up true over the center of the bore, and the casing sunk, say 8 ft., as before described, to start the whole fair; then the drills may be lowered into the bore and started. From the sketch given of the gearing it will be seen that the horse-power or engine may be kept constantly going, clutches being provided for throwing either of the barrels or the pitman sheave into gear when required. When the clutch at *b*, Fig. 45, is put into the gear, the pitman sheave is given an up and down motion, equal to twice the throw of the crank on the end of the shaft, *c*. As the drills sink the rope is lowered out by applying a pinch bar or feed lever to the brake wheel, *e*, and bearing down on it till the pawl, in the wheel on the end of the cable drum, *d*, can be released; then hold the brake and lower out as much cable as may be necessary, and when the tools reach the bottom, again throw in the pawl. The lever marked *f* is for working the clutch, *g*, which travels on a feather on the driving shaft and engages the cable drum for raising the tools. The lever, *h*, is for tightening the belt on the pulley on the driving shaft, and enabling it to drive the barrel, *i*, which carries the sand pump line; this may be a light wire rope, to the end of which is attached the sand pump. It will thus be seen that the tools can be raised rapidly by the cable drum; when they are up and landed, disengage clutch, *g*, drop the sand pump into the bore, easing it down if necessary by pressing on the lever, *h*; and when filled again press on lever, *h*, and the sand pump is rapidly wound up, the engine or horse-power being kept in motion all the time. Thus a very few minutes suffice for raising the tools, clearing out the hole, and lowering the tools down to work again; and the whole operation can be attended to and manipulated by one man, a second man only being necessary for driving the engine or horses; the assistance of the second man is also necessary when it comes to building, and driving or sinking the casing.

When the whole is first started, the tools may be kept short by omitting the sinker bars and jars. Should the hole be dry, water must be poured in from time to time, and when the tools stick, draw them and clear out with the sand pump. As soon as rock is met with, it is necessary to add on the jars and sinker bar, otherwise the tools may stick fast in the hole; the loose action of the jar enables an upward blow to be given, by shortening in the cable and continuing to work the pitman sheave; when an upward hammering action is imparted to the tools, this seldom fails to start them up. Should the tools be found to stick through the hole getting out of shape, a reamer should be used to true up the hole before proceeding with the drilling.

The description above given more particularly refers to the Gillespie Tool Company's machine, but the same will almost exactly apply to the Pierce machine. I saw both machines at work at different places, and on the whole would give the preference to the Gillespie apparatus, as being the more compact, but in actual work I doubt whether there is any practical difference between them; both being good and well-designed machines, and, I believe, the best for the work to be found in the States.

Pennsylvanian Rig.—As I have referred to the Pennsylvanian oil rig, a brief mention of its principle may not be out of place here. This machine is specially arranged for deep sinking when bores 1,500 ft. to 2,000 ft. or over are necessary. In this case the tools are made up exactly as before described, but larger and much heavier; tools 4 in. in diameter and 55 ft. to 60 ft. long are generally used for deep 7 in. and 8 in. holes.

Over the site fixed upon for the hole is constructed a derrick, which should be not less than 70 ft. high, 20 ft. square at the base, and 3 ft. 6 in. at the head. The corner timbers of the framing may be 6 in. by 6 in. pine, or 4 in. by 4 in. hard wood, well braced on all four sides, horizontally and diagonally. At one side is firmly set up a Samson post, on the head of which is placed the walking beam. Under the outer end of the walking beam is placed a bull wheel, carrying the cable, and on its end a crank, or what was before termed the pitman, for imparting the reciprocating motion to the walking beam. The bull wheel is driven by belting from a steam engine, set up in a shed some 20 ft. back. From the inner end of the walking beam is suspended a rod, with the temper screw attached thereto. The bore is usually started by what is termed spudding, *i. e.*, working the tools direct from the bull wheel, lifting and dropping by slackening or surging the rope on the wheel; once they are their own depth below the surface, the walking beam is brought into play. The rope is thrown off the bull wheel, and the end caught by the temper screw; the drilling motion is then imparted to the tools, and as they sink, the temper screw is slacked out, thus lowering the tools, at the same time turning them and preventing their striking twice in the same place. The nut of the temper screw is split, and held by a clamping screw, so that the leading screw can be quickly shortened in by slacking the clamping screw; at the same time a corresponding length of rope must be given out, by releasing and re-clamping it in a fresh place. When the bore needs clearing out, the rope is taken on to the bull wheel, and the tools quickly run up; the sand pump, which is worked by a light line on a second reel, is lowered down, and the hole cleaned out. In all operations of drilling too much care cannot be taken to insure the bit or drill being kept up to proper gauge. For this purpose it is desirable to have a duplicate of each pattern of bit used, and with the help of a portable forge, which should always accompany a drilling outfit, a spare bit can be forged to gauge and got ready for work again without delaying the drilling. The club bit, with its hollow or grooved center, is specially designed for conveniently forging to gauge.

This class of drilling has been carried on to such a vast extent through the oil regions that the men engaged in the work have become remarkably expert, so much so, indeed, that a bore 1,200 ft. deep can often be put down in about twenty-five days, and at a total cost of about 2,000 dols. (say 400 *l.*). I visited the Bradford, Pennsylvania, district early in June, 1883, and saw from local statistics that during the month of May 226 bores had been completed, and on the 1st of June that year 384 bores were in progress in the neighborhood.

Upon completion of the bore, and if oil has been struck, the derrick, together with the walking beam, engine, etc., is usually left in place; for although the hole may spout oil at first, it will most probably cease to flow after a time, and then pumping must be resorted to. A pump barrel, with the necessary foot valves, etc., is then let down the bore and there fixed and worked by long sucker rods, the upper ends of which are attached to the walking beam, which, as before described, is set in motion by the engines and the oil thus pumped to the surface; but should the bore prove a failure and miss the oil, then the rig is usually removed, but in some parts, where timber is plentiful and cheap, it hardly pays to dismantle and remove the derrick. Throughout the oil regions the hillsides and valleys may be seen thickly dotted over with derricks in all directions close together.

Although I have described the Pennsylvanian rig at some length, I hardly think it will be necessary to introduce it into this colony for the purpose of searching for water.

Casing.—Hitherto I have referred to casing in connection with the bores, but without describing it. A few words as to the various kinds of casing, their manufacture, and mode of sinking, are here necessary.

The class of casing I saw almost wholly used in California was what is termed riveted sheet-iron casing. It is usually made from No. 14 B. W. gauge sheet iron, in 2 ft. lengths, double thickness; at the bottom is a forged steel shoe (see Fig. 31), turned with a cutting edge, and bored internally for the reception of a short length (about 14 in.) of inner casing, to which it is riveted; outside this comes a 2 ft. length of the outer casing, which then stands 1 ft. above the inner length. The tube is then built up of alternate lengths, each 2 ft., of inner and outer casing, thus breaking the joints 12 in. The casings are made an accurate fit for one another, well tarred before driving together, and two or three rivets put in to secure them.

In a country where saline waters are met with, it is doubtful whether it would be wise to use this sheet-iron casing, there being so many surfaces exposed to corroding action that probably the iron would not last long; in most cases, therefore, it will be found cheaper in the long run to use the more expensive screwed tubes hereafter described.

The boring or drilling tools, having to work within the casing, necessarily leave a considerable amount of the surrounding soil to be cut away by the cutting edge as the casing is forced down; this is found a desirable arrangement, as it insures a close fit which cuts off surface or bad water contained in the upper measures from the pure artesian water reached at lower depths.

Should a hard vein of indurated sand, or soft rock, be passed through by the drill it may be found almost impossible to force the casing through it; in this case the side must be reamed out by an expanding reamer, such as shown on Figs. 5 and 6, thus enlarging the bore to the outside diameter of the casing.

The most usual method I found practiced of sinking casing was with a lever, as shown at Fig. 34; some planks are buried in the ground, or otherwise suitably loaded to secure the fixed end of the lever to, and then the other end of the lever, which rests upon the casing, is weighed down, either by the weight of the men, or by applying a purchase tackle to it. A suitable cast-iron cap must be placed over the head of the casing for the lever to rest upon during the operation of sinking, to prevent its being crushed or injured.

In some ground the casing sinks very freely. I saw some sinking by its own weight when at a considerable depth (over 150 ft.) below the surface; it very frequently happens, however, that the surrounding friction becomes too great to admit of the first or 7 in. casing being sunk over 200 ft ; when this happens, a 6 in. casing must be lowered down inside till it reaches the bottom; the boring may then proceed as before, but of course with a smaller bit; the weight of the free length of the 6 in. casing helps very materially in the sinking, it will occasionally follow the auger for as much as 70 ft. below the 7 in. casing before any forcing down becomes necessary. As soon as water is reached and the boring is stopped, the 6 in. casing can be cut off about 8 ft. or 10 ft. above the bottom of the 7 in. casing by the tool shown at Fig. 9, or a tool somewhat similar to the reamer shown at Figs. 5 and 6, and the upper portion drawn out, taken apart, and used again in another hole; the same tool used for lowering the casing can be used again for drawing it up.

Another method of sinking the casing is by using hydraulic pulling jacks. A suitable cast-iron head, which carries a hook at each side to attach the pulling chains to, is fixed over the pipe; two 4 or 5 ton pulling jacks are buried in the ground, one at either side, their lower ends being securely fastened to a framing, which must be previously buried in the ground some 8 ft. deep round the casing; the jacks are run out full length, and the long linked chains upon being drawn up tight are attached to the hooks in the casing cap; the jacks are then pumped down, drawing the casing with them; of course when steam is used this is a simple process, still it is effectively, although at a much slower rate, done by hand. This method has the advantage that one man can be pumping or forcing down the casing at the same time that the other men are carrying on the boring.

A third method of sinking casing is by driving it; this is very simply done when a drilling machine such as the Gillespie Company's is used; for by taking a bolt out of the pitman crank a peculiar drop action is given the pitman sheave; it is then only necessary to detach the drills from the end of the cable, hang on the driving weight, place a good block of wood over the head of the casing, with a hole through it to guide the pin, then start the machine and a series of rapid blows can be given to the casing sufficient to drive it down.

Cost of Casing.—The cost of the 7 in. riveted casing, double thickness, delivered on the ground in California, I found averaged 75 cents (say 3 s. per foot), and the 6 in. similar casing cost 60 cents (say 2 s. 5 d. per foot); this is based on sheet iron costing 3 d. per pound =28 s. per hundredweight, delivered on the ground.

One great advantage in the use of riveted casing is that the sheets can all be cut and punched true to gauge for inner and outer lengths at the factory, and a number of plates can be safely packed together and conveniently sent up the country, where a very simple curving machine can be at hand to bend them; they are then riveted with cold rivets. There is nothing in the whole process that any handy man could not learn to do in a very short time, with the very simplest appliances.

A more permanent class of casing is made from lap-welded tubes, which can be procured in lengths up to 18 ft. or 20 ft., turned and machine screwed at the ends as shown at Figs. 32 and 33. As this class of joint cannot be made on pipes less than about $\frac{3}{16}$ in. in thickness, the cost of such casing is considerably greater than the riveted, but it would certainly be found more durable and safer to use in sinking. The cost of such casing properly screwed, landed in Sydney, would be about 7 s. per foot for 7 in., and 5s. per foot for 6 in., assuming it to be obtained in fair quantities. There are various ways of making the screwed joints, two of which are shown en Figs. 32 and 33. The latter is the cheaper, but that shown at Fig. 32 is the better, being the only one that secures a flush surface inside and outside the pipe, which is a most important matter.

A cheap casing is sometimes used in America, made in lengths of 14 gauge sheet iron wound spirally and riveted along the edge. I do not think this can be recommended except in very soft ground, for it is not strong enough to stand the end crushing strain necessary to be applied when pushing it down the bore.

Stopping back Impure Water.—When practicable, it is desirable to use casing all the way to the bottom of the bore, but this is really only possible when the boring is through soft measures free from rock; when rock is met with, the hole ought to be reamed a little, and the casing let as far as possible into it to cut off the downward flow of impure water; but should this not prove effectual to stop back the impure water, some device such as that used in the oil wells for stopping the water back from the oil must be adopted. The method for doing this which I heard was most approved of in the oil regions, where it has been applied to nearly every bore to keep the oil free from water, is by the use of what is known as a "cap packer." This is a rubber block 8 in. or 10 in. long, made almost the neat diameter of the bore, and lowered down on the end of an inner tube. In Fig. 37, *a* is the rubber block; *b* the inner tube, which of course must be carried up to the top of the bore; *c* is the lower tube resting on the bottom of the bore, which in the case of pumping wells acts as the pump barrel when fitted with a foot-valve, the upper valves being attached to the sucker rods; on the top of the lower tube, *c*, is screwed a funnel-shaped piece of pipe, *d*, which widens out nearly to the diameter of the bore, and is turned with a seat on its upper rim to receive a ferrule, *e*, which slides on pipe, *b*, and acts as a seat for the rubber block; pipe, *b*, has a stop ring, *f*, screwed at its lower end to prevent the block sliding off when bein, lowered down, and another ring, *g*, at the top end to catch under a malleable iron ring fixed into the rubber block for the purpose of drawing it from the well when required; there is another collar, g^1, screwed on, which fits the upper end of the rubber block, and bears down on it; this also acts as a joint collar for the pipe. The action is therefore as follows: The lower end of the block rests on the head of the lower pipe, and the whole weight of the upper pipes rests upon the top edge of the block, thus compressing and expanding it against the wall of the bore, and effectively stopping the downward passage of impure water.

In the case of artesian flowing wells, the lower pipe, which is not necessary, can be dispensed with by using the same apparatus, but by inserting a crossbar, *h*, Fig. 36, and attaching to it a one-half inch rod of iron, which should be in long lengths screwed at the ends and coupled together and led up to the top of the bore; the inner pipe, carrying the packer at the bottom, must then be suspended from the surface, and the one-half inch rod screwed hard up to bring an upward pressure against the rubber block and thus expand it.

There is another simple way to make a water-tight joint as shown at Figs. 35 and 38. This consists of an iron tube, *a*, say 4 in. in diameter, with a flange, *b*, screwed on at lower end, against which are bolted two rubber rings, one, *c*, about 2 in. larger in diameter than the bore, the second, c^1, placed underneath a tight fit for the bore; these are nipped up against the flange with a ring washer, *e*, and screw bolts. A calico bag about 2 ft. long and made the diameter of the bore is secured at its lower end between the flange, *b*, and the rubber ring, *c*. This bag, which incloses an annular space round the tube, is filled with a mixture of half Portland cement and half clean sand just moistened and made into a stiff mortar; the mouth of this bag is loosely closed round the pipe, which is then pushed down the bore till the bottom reaches sound rock, at a point below the strata containing the salt or impure water; the cement may then be tamped firm home by a piece of heavy tubing, or annular cast iron weight suspended by a rope as shown on sketch. The cement will soon set hard, and make a secure and tight joint.

Cost of Machines and Tools.—The cost of the Gillespie or Pierce machine, including an outfit of one rope socket, one auger stem, sinker bars and jars, two bits, two winches, sand pump and 500 ft. sand line, 500 ft. of drilling cable, and a horse-power, the whole suitable for drilling 500 ft. deep, would be about 200 *l.* delivered in Sydney, to which might be added about 30 *l.* for extra fishing tools, pipe riveters, lifters, stubs, etc., making an outfit in all cost about 230 *l.*; but even this would have to be exceeded in the first instance by any one commencing to bore, as it would be necessary to provide a portable forge, some blacksmiths' tools, spare iron, etc. For going 600 ft. somewhat heavier tools would be necessary, but with the same machine the cost would be about 240 *l.*; by purchasing a supply of spare box and pin stubs, a great many of the special tools shown on the drawings could be made by any ordinary blacksmith and the stubs closed on.

The boring machine outfit would not cost over 80 *l.* complete. Excepting the horse-power and crab winch with connecting gear and the screwed ends for the wooden and iron pipe rods, there is no part that could not be made up the country by any carpenter and blacksmith. Most of the machines of this class which I saw at work were evidently constructed by the owners, who in most cases, I found, had been mechanics, blacksmiths, or general handy-men, well able to make all their own tools, as well as the numerous special tools that are found necessary from time to time during practical working.

In situations where many bores may have to be put down, and where water and fuel can be conveniently obtained, I would certainly recommend the use of steam instead of horse-power, for expediting the work, and thereby lessening the cost of labor. Almost any make of portable engine can be adapted for the purpose. To run a 600 ft. drilling apparatus, an engine of about 5 horse-power would be ample.

For the generality of work, however, I believe the ordinary horse-power machine will be found sufficient, though of course slower, both horses and horse keep being cheap and always available throughout the country.

It is unnecessary here to refer to the cost of steam engines, as full information can always be obtained from any Sydney importer.

American well-drilling tool catalogues quote prices for engines, but English-made engines can be landed in Sydney much cheaper.

Cost of Boring or Drilling.—As regards the cost of boring or drilling, I found nearly the one price ruled all through the country; no matter what kind of apparatus was used, a set contract price seems to have become established. What the net cost was I could not well find out, but of course it would vary a little in every case; but seeing the eagerness with which contractors sought for and took orders, it is evident the contract quoted below pays well.

The rates are as follows :

ft.		ft.	ft.	s.		£	s.
0	to	100 =	100 at	2	per foot	10	0
200	"	300 =	100 "	3	"	15	0
300	"	400 =	100 "	4	"	20	0
400	"	500 =	100 "	5	"	25	0
500	"	550 =	50 "	6	"	15	0
550	"	600 =	50 "	7	"	17	10
Cost for boring hole 600 ft. deep						102	10

To this must be added cost of casing, which, as before mentioned, cost when riveted 3 s. per foot.

	£	s.
600 ft. 7-in. casing, at 3 s.	90	0
Add to this the cost of boarding the contractor and his two men, as I found it was the practice of the farmers for whom the work was being done to keep them while at work, say, three men for six weeks = one man for 126 days at 2 s.	12	12
Total cost for a 600 ft. hole	205	2

Say 6 s. 10 d. per lineal foot.

If a length of 6 in. casing had to be used, the cost would be reduced a little. I have allowed six weeks for the boring; this is the outside time a 600 ft. hole would occupy, unless some serious mishap occurred to delay the work. I have already mentioned a case where with the hydraulic boring apparatus a hole had been sunk over 500 ft. in 11½ working days. It must be borne in mind, however, that in this case a steam engine was used, and when an allowance is made for procuring water, fuel, stores, etc., the cost of the work will nearly mount up to as much as the slower horse-power machine.

Arrangement Adopted in California for Irrigating from an Artesian Well.—Upon the completion of a bore, if it prove a flowing well, the casing is left standing 4 ft. to 5 ft. above the surface; an area of about an acre is then inclosed to form a reservoir around the well, by raising a mound of earth, say 5 ft. high; the land around is cut up into about 5 acre paddocks, termed "checks," and properly leveled off for irrigation; four main feeders, termed "ditches," are constructed from the central reservoir along the boundaries between the checks, the bottom of the ditches being kept a little above the surface of the check; very simply constructed wooden gates are placed at the opening to each ditch, by raising any one of which the water can be led along the ditch and again let out through side gates over any one of the surrounding checks needing irrigation. It will thus be seen that the storage reservoir, which holds about 1¼ million gallons, is filled by the well, and emptied daily, or as the land needs it, by running the water off through the various ditches. I was informed that the farmers generally considered a good well sufficient for irrigating from 160 to 200 acres of tilled land.

I experienced great difficulty in obtaining information as to the quantity of water discharged from any of the wells; the amount of course varies considerably. Only in one or two instances could I get near the tube to measure the height the water rose over the lip of the pipe, for, as already mentioned, they invariably stood out in the center of a round reservoir some 4 ft. or so deep.

I measured a few that I gained access to, and in these instances I found the water rose from 2 in. to 3 in. over the lip of the pipe, the local practice being to speak of the well as an inch, 2 in., or 3 in. flowing well, as the case might be. I only saw a few 3 in. wells, and they were considered among the best. I estimate the discharge from a 3 in. well would be about 550,000 gallons per twenty-four hours, and from a 2 in. well about 350,000 gallons per twenty-four hours. Of course there are cases where the artesian water rises under very heavy pressure. When such are found, pipes can be connected with the casing tube, and the water led away for supplying buildings.

A portion of the town of Honolulu, in the Sandwich Islands, is supplied from an artesian well in this way. I there saw some wells discharging under very heavy pressure. One was throwing water through a 5 in. pipe to a height of at least 25 ft. into the air; but in California I did not see or hear of any such wells.

Torpedoing Wells.—The system adopted in Pennsylvania known as "torpedoing," for increasing the flow of oil wells when first bored, might perhaps be found of use in artesian wells.

When the oil-bearing strata is reached, and the boring is considered deep enough, a heavy charge of dynamite, with a fuse attached to it, is let down to the bottom of the well; or better still, the dynamite charge may be lowered down with insulated wires attached, and when on the bottom fired by a portable battery on the surface. The explosion shatters the surrounding rock, opening the joints, and allows a free escape of the oil to the bore. Although this method is almost universally adopted in oil wells, I never heard of its being tried in a waterbore, but I think the experiment would be worth trying with a light charge in a case where water may be met with on strong ground.

Suggestions as to Importing Apparatus.—I have not had an opportunity of making myself acquainted with the nature of the apparatus that has been tried or now is being used in this colony for drilling or boring for artesian wells. I am aware the diamond drill is being largely used for boring to test for minerals, but for the purpose of obtaining a water supply such drills are quite useless owing to the small bore. Diamond drills can, of course, be made for all sizes up to 20 in. or 24 in. in diameter, of which latter size I have seen one, but when the ordinary small bore is exceeded, the cost increases rapidly. Should the government not have already imported any machine such as I have described in my report, I would recommend that an order be sent to either the Gillespie Tool Company or the Pierce Well Excavator Company—or, perhaps, to both—to send out a machine and complete outfit suitable for drilling 500 ft. to 600 ft. deep; also, that they be requested to send out an experienced man with their machine to work it here upon arrival. I am sure either of the manufacturers would for their own sake select a skillful and trustworthy man who would soon train others here into the work. Should the department in charge once show that boring can be done expeditiously and at a reasonable expense, I am persuaded that private enterprise will not be slow in coming forward to import the appliances found most suitable, and that in a few years' time the government will be entirely relieved of the trouble of carrying on this work, except through the medium of contractors. —*Engineering.*

SAND BAG EMBANKMENTS.

AT a recent meeting of the Engineers' Club of Philadelphia, Mr. Percy T. Osborne presented an illustrated description of the Sand Bag Embankment to close Little Inlet on Brigantine Beach, N. J., which was constructed by his father, Mr. Richard B. Osborne, C.E.

The closing of this inlet, the width of which was 831 feet, with a rapid current at ebb and flow of tide, never was deemed possible with the very fine sand which was the only material at hand.

The changing character of this shore, under the action of the northeasterly winds, the laws of nature and the results they had in years past produced on this beach, the possibility of making these coworkers in producing like results in a shorter period of time, supplied the only expectation that, with the means possessed, this waterway could be obliterated, and a large area of land redeemed from the sea.

By closing this stream for a short period, it was expected that the sea would form rapidly what it would require perhaps a century otherwise to accomplish, and that the accretion from the sea would quickly protect and cover up the works of construction, without which it was utterly useless to attempt to build a barrier against the ocean, out of the material available. The expectation has been proved to have been founded on correct principles. The sea has performed its part

most fully. The operations of nature's laws have been quickened, and the Inlet, to-day, is a thing of the past. The sand was packed in ordinary salt bags, costing 5½ cents apiece, sewed up and placed in the embankment, at a cost of 66 cents per cubic yard for bags, and 34 cents per cubic yard for filling, sewing, and placing, making a total cost per cubic yard of one dollar. The working hours were between half ebb and half flow of tides. The embankment was made from each shore simultaneously, to within a foot of low water, by placing the bags by hand. On these bags, frames, six feet in height, twelve feet broad on top, and three feet apart, were placed, and connected by planks spiked on the sloping sides. The interior spaces were filled with sand bags, 80,000 of which were used in the construction of the embankment. About 1,050 were placed in a day of ten hours, twelve of them equaling one cubic yard. At low tide, the water in the main channel was thirteen feet deep when the bank was begun, on June 17, 1881. On the 5th of August following, the embankment was closed and the sea shut out—in 42 working days—and where the deep channel had been, there was then less than two feet of water; the deposit of sand from the sea having commenced with the embankment and increased as it progressed. For nine days after closing, the embankment withstood the heavy seas and southeasterly gales. On August 12 the sea broke over the banks, near the north end, where the water was two feet deep. Having some bags on the ground, this breach was closed on the next ebb tide. On the 14th another breach occurred, when there was nothing at hand for its repair, the bags ordered on August 6th not having been supplied for 18 days. When they did arrive, the company had discharged the contractor, and the breach had only to be left to itself. It continued to widen up to 16th of September, when it was 132 feet, with 16 feet depth of water below the original surface. The old 13 foot channel remained closed, and three bars from the banks seaward had been created. It was expected then that the accretion would still continue, and that finally, in spite of the breach, the closing of the original channel and the alteration of the course of the tide would continue the deposit and finish the undertaking without further efforts. Something was attempted afterward by one of the company, by driving poles and stretching light wires along them, but these *petite* attempts conduced in no wise to the ultimate result. The increased action of the sea finally obliterated the inlet, and covered the whole locality, thus proving that nature had fully performed what had been expected of her; 70 acres seaward and 20 acres inside were reclaimed.

SHAKESPEARE MEMORIAL TOWER, STRATFORD-ON-AVON.

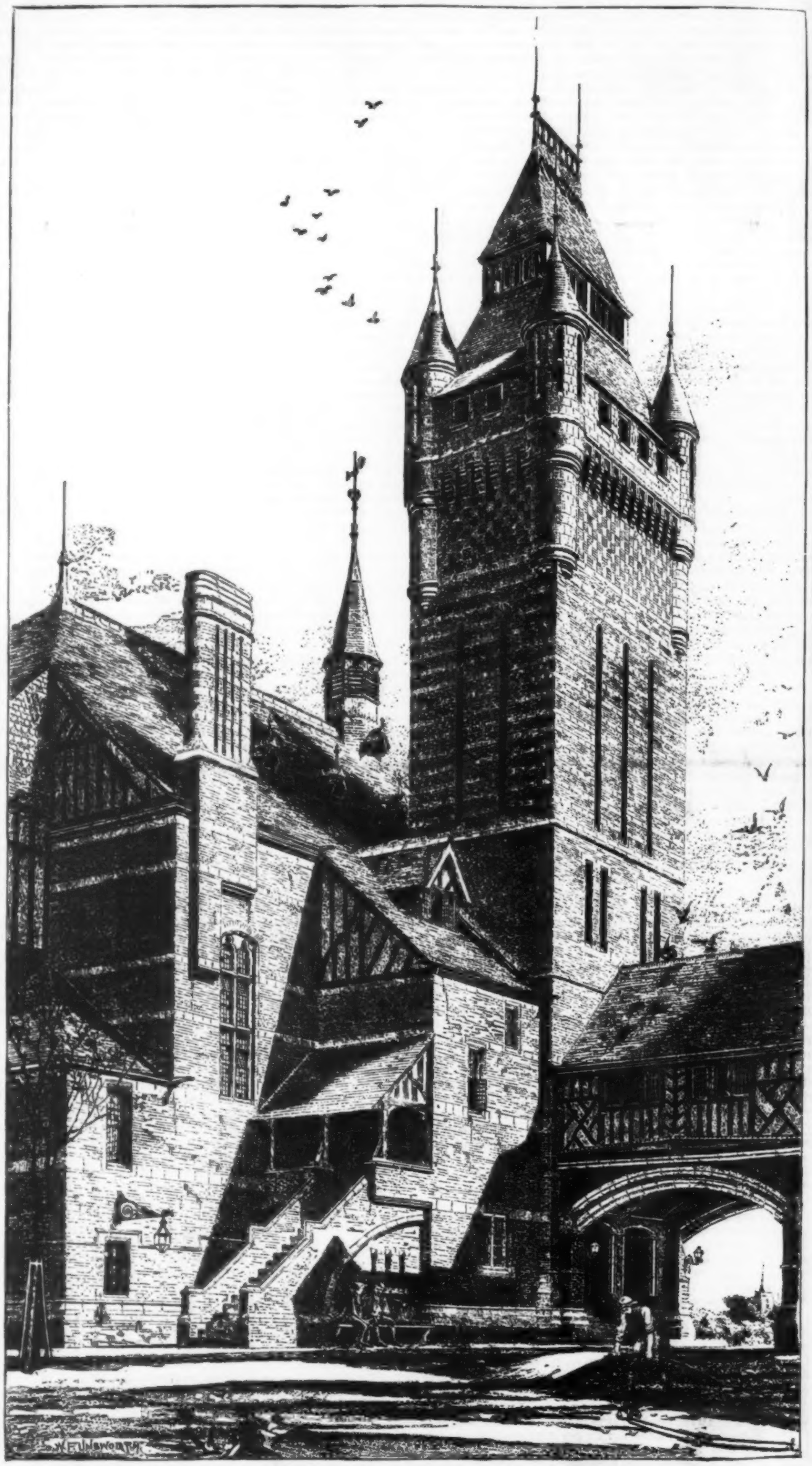
OUR illustration represents the tower, the completing portion of the Shakespeare Memorial, the foundation stone of which was laid about eight years ago. The tower was finished last year, at a cost of £1,600, making the total amount spent on the memorial about £25,000. The view shows the entrance to the gallery of theater, and the bridge which connects it with the library and picture gallery. The tower contains large tanks, which are kept constantly supplied, by automatic pressure, from the river Avon, which flows past the building. The work was executed by Messrs. W. H. Lascelles and Co., from the designs of Mr. W. F. Unsworth, Great Queen Street, Westminster.—*Building News.*

BUILDING RESTRICTIONS.

THERE are certain useful building covenants sometimes inserted in building agreements and leases with the object of restricting the lessor or vendor, or of preventing the lessee, from doing certain things or of enjoining him to make certain provisions. The value and importance of these covenants, both in the interests of lessors and lessees, will be fully appreciated by all who have noticed the progress of building operations on estates; but unfortunately a near-sighted policy is found generally to prevail, to the detriment of the new estate and those who tenant it. These restrictive clauses have generally reference to both parties. Thus, the lessee is to observe a certain line of frontage or height in the building he erects, so as to secure uniformity in design and style; to complete the building to the satisfaction of the lessor or his architect, and to expend a stipulated sum at least; not to build for certain trades and injurious businesses, to pay an apportioned part of the expense of roads and sewers, and such like. The lessor on his part covenants to use the land adjoining that leased in a certain manner; to build houses on the other parts of the estate of a stipulated value, and to lay out the roads. How far these mutual obligations on the part of lessor and lessee are carried out it would be perhaps rather difficult to say; our only means of judging of this is to examine the actual results as they appear in newly laid-out building estates. Our observation at least has shown us much apathy and remissness on the part of the contracting parties, or a considerable relaxation of covenants, if they ever existed at all. Judging from an architectural point of view, the results are anything but satisfactory, for if uniformity be aimed at, and it is not always desirable that it should be, the houses suffer the degradation of dullness, which depresses and chills, or, if not, license and caprice are allowed to run to a wanton excess. Of course we cannot expect anything like good architecture under the usual conditions of leasehold tenure; but there may and ought to be some standard set up. The way estates are generally managed is for an enterprising builder to take the land, and build on the condition that leases shall be granted him when the houses have been covered in or completed; or the builder may take the land on building leases, subject to a reserved ground rent, and sublet or create leasehold or "improved" ground rents. The builder under this system generally makes his own terms, and the restrictions are minimized, the estate being sacrificed between the parties.

Let us imagine for a moment what would be the result if the "middleman," as the builder often is, did not appear on the scene, but the plots were let to independent builders. One important result of the the transaction would be properly drawn up covenants. It would not do to allow one builder to spoil the whole estate by erecting an inferior house, or one likely to destroy the letting capabilities of the other plots. A substantial erection is the result, and, what is more common, a larger piece of land is taken than when a builder treats for the whole, and wishes to make as much as he can out of the land. In all probability the builder proposes to live in the house himself; he does not wish to make a builder's or agent's profits.

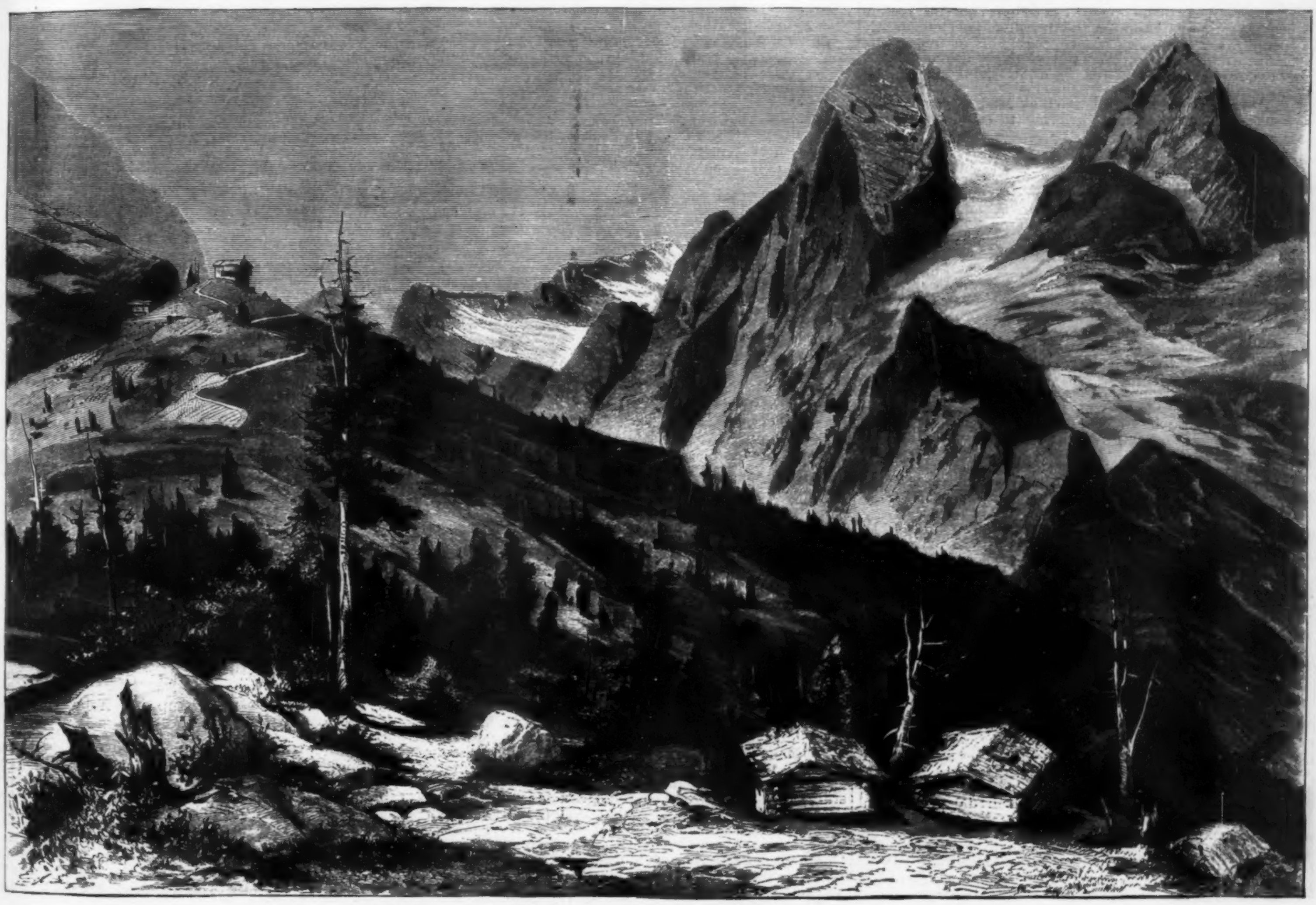
We may here consider a few of those covenants which affect building estates, and which tend to improve the character of the houses. The first restrictive covenant has reference to open space. The lessor or vendor binds himself not to build on land adjoining what has been conveyed, and the lessee on his part covenants not to build on a certain portion of the ground demised. The value of such a restriction may be illustrated in several ways. A man may be so inclined as to cover his plot entirely with buildings to the injury of his neighbor's light and prospects; or a building or out-building may be so far extended or built as to shut out the sun from his neighbor's house. A lessee in the same manner may be grievously injured by the lessor in building or permitting buildings too near him. Thus in Rankin v. Huskisson, the commissioners of woods and forests, who had granted a lease to the plaintiff as a site for a club house, and had covenanted that part of such land adjoining should be laid out as an ornamental garden, and that no buildings should be erected thereon, were restrained from erecting buildings on that part. The order of the court restrained also the defendant, their agent, from permitting a part of the buildings already erected on the ground from remaining on it. A covenant not to build upon land will be enforced, and an injunction will be granted against the continuance of buildings erected contrary thereto. If this restriction were more generally introduced into building leases or conveyances, there would be more open space left round suburban houses, the lessee would be subject to fewer hardships, such as a total deprivation of light and air, or of prospect, after he had expended a large sum of money in erecting a house upon a once eligible site. Nothing can be more annoying, after a brief enjoyment of a garden in the rear of one's house, than to find a lofty erection or extension of the adjoining house, made so as to entirely cut off the access of sun; but such deprivations are commonly endured in the suburbs of London when estates are opened up for building. A more usual and not less important restriction is that a "building line" be observed. Even here we find violations of covenants taking place without observation. A bay window is added, or a porch, both of which are held to be "buildings" within the meaning of the covenant. The adjoining



SHAKESPEARE MEMORIAL TOWER, STRATFORD-ON-AVON.

owners or occupiers take no notice of the addition unless it be so close as to seriously impede the view or invade privacy, and in time a projection is made to the house, a gable is thrown out, and further encroachments follow. Legal decisions upon this point are clear enough. In the case of Lord Manners v. Johnson, a purchaser of a plot covenanted not to erect any building nearer to the road than the line of frontage of the then present houses in the road. They were about 40 ft. apart and about 80 ft. from the road, and he was "to observe a straight line of frontage with the line of houses." He erected two houses with bay windows carried up from the foundation to the roof, and projecting 3 ft. beyond the line of existing houses, which were held to be a violation of the covenant. The court also held that this was invasion of privacy, and constituted damage, and that it was not necessary for the covenant in terms to purport to preserve privacy. A bow at the rear of a house has also been decided a violation of the same covenant, and an injunction was granted. (See Western v. Macdermott.)

The value of property is often appreciably injured by building opposite or within a certain distance of the front. Vendors often covenant that no buildings other than a certain kind of dwelling house of a certain amount shall be erected opposite to the purchaser's land, and this restriction is very reasonable, for it may so happen that the purchasers of land on the opposite side of the road may, if not restricted, put up an objectionable building. In Bowes v. Law the vendor covenanted, not to erect buildings except dwelling-houses, to cost at least £200 each, to front with the road opposite the plaintiff, while the defendant opposite agreed to put up a permanent fence round the land from 4 ft. to 7 ft. high, and to enter into a like covenant with the plaintiff. The defendant afterward built a garden wall alongside the road 8 ft. 6 in. high, and in one part 11 ft. high, and a vinery with lean-to roof. The latter higher part of wall and vinery were deemed breaches of the covenant. This restriction applies equally to the height of buildings within a certain distance from other property. If a prescribed height is covenanted the law will restrain any departure from it. The necessity of restricting the height of houses on an estate is obvious enough, and hardly needs dwelling on, but it does not appear that the rule "not to build opposite" is often made a covenant. In a terrace, for example, the vendor of a piece of land with a house ought to covenant not to build opposite if such land belongs to him; but it has been ruled that the meaning of the words "not to build opposite to plot of land" conveyed, is intended only to apply to that part of land immediately opposite to and of the width of the said plot. With regard to prospect, there is no rule in law which makes it a nuisance to obstruct a prospect or view. Such a right must be acquired by grant or covenant, and therefore those who select a plot of ground for building from which a distant prospect can be obtained, ought to take care and acquire a right of view. Though the law takes no account of such injuries, it is one that will nevertheless weigh heavily in the minds of many people. The loss of a prospect is a serious deterioration of a residence, and must depreciate its value. Thus we can imagine what the loss of a sea view would be by the erection of buildings in front or in the rear. A row of houses and shops built in front of a residence which has enjoyed a good prospect is a serious mischief. In towns this kind of deprivation does not affect the owner much; but in residential suburbs the inclosure with buildings of an inferior class is always depreciatory in value. It is almost needless to point out a dozen or more localities round London where the owners of good properties have become victims of this malady—and we can call it nothing else—of being crowded up by inferior dwellings erected before their very windows. People must live somewhere, we are told, and to meet the demand for houses at a reasonable distance from town, estates and properties sold and let only a few years ago in favorite localities are now threatened with an invasion of "jerry" buildings it is almost pitiable to behold. The gardens, once luxuriant and little paradises in their way, oases of verdure in the desert, are without compunction sacrificed for ground rent; even front gardens and lawns are being robbed by the insatiable greed of speculators. But a limit might be set somewhere if those who sell or let land on lease, and those who purchase or become lessees, were to insist on restrictive covenants being introduced into their conveyances and leases, such as we have pointed out. Additional benefit would be secured in new localities if the legislature were to require every estate laid out for building to appropriate a certain portion of the land for recreation or garden ground—the extent to be regulated by circumstances, such as the size and area built upon. A certain allotment per house for garden, together with one rule now generally introduced, though not always acted upon, to prohibit the erection of buildings for trades and businesses, would insure for our residential estates, and for the purchasers of land on them, an immunity from the injuries which threaten them. There would then be no difficulty in restraining the speculative builder, and of preserving those advantages which a purchaser or tenant has a right to expect.—*Building News.*



THE KING'S HOUSE ON THE SCHACHEN MOUNTAINS, BAVARIAN ALPS.

THE KING'S HOUSE ON THE SCHACHEN MOUNTAIN, BAVARIAN ALPS.

THE village of Partenkirchen is one of the favorite resorts of tourists in the Bavarian Alps, as it is surrounded by the most beautiful Alpine scenery. One of the grandest mountains in this region is the Schachen, which is 5,725 ft. above the level of the sea; and an excellent view of the surrounding mountains, valleys, lakes, etc., can be obtained from its summit. King Ludwig II. of Bavaria erected a plain Swiss cottage, known as the King's House, on this mountain. He frequently retires to this lonely spot to enjoy the grandeur and quietness of nature.—*Illustrirte Zeitung.*

PURIFYING BEESWAX.—A bee-keeper writes: The best plan that I know of is to melt ten pounds of wax in a vessel, after having first put in the same one pint of strong vinegar, together with one quart of water. After all is melted, set the vessel from the fire and wrap it in several thickness of blanket or old carpet, so it will cool slowly. By this plan the wax is in agitation while liquid, and all impurities worked to the top or bottom. If strained before putting through this process, there will be nothing but fine dross at the bottom, with nothing on top.

SILVER PRINTING.

MR. ELLERSLIE WALLACE in the *American Journal of Photography* says on this subject: A silver print on albumenized paper is made by the action of light on a curious mixture of organic and inorganic bodies. The actual sensitive surface consists: (1) of a compound of albumen and silver (sometimes called albuminate of silver), (2) of chloride of silver, and (3) of free nitrate of silver in varying amounts.

Besides what has been already mentioned, we must not forget that a small portion of the image rests on the surface of the paper itself, as can be seen in a blistered print when the loose albumen coating is torn off, so that the image (although faint and weak) will be found on the paper below.

Experiments conducted with these substances alone might well lead to the belief that nothing like a satisfactory result could be made with them. For instance, nitrate of silver is not *sensitive to light.* We frequently see large crystals of this salt exposed to full daylight in exhibitions and other places, and occasionally may notice a slight discoloration, but this is attributable merely to the presence of more or less dust which has gained access to the salt in the process of preparation. Here, then, we have at once an organic compound of silver with the various matters of which the dust is composed, and the compound is reducible by light, giving the gray appearance. But as we remarked in a former article, the commercial nitrate of silver is now of so excellent a quality that it will often remain perfectly white even after prolonged exposure to the light, thus proving its freedom from organic contamination. Chloride of silver behaves quite differently from the nitrate in presence of light. If freshly precipitated chloride be exposed to the sun, it will immediately become bluish violet in color, deepening to purple or light slate color. Under no circumstances can the pure chloride be made to become *black* by exposure to light, though it is quite sensitive.

The peculiar compound between albumen and silver when similarly exposed becomes at first pale cherry-red, and it is not until after a comparatively long time that it becomes of a dark reddish or maroon tint.

Now, bearing these facts in mind, we find that in the case of a sensitized albumenized paper, we have the two compounds with an excess of nitrate of silver. This excess is indispensable to the formation of a vigorous image. It stimulates the change produced by light on both of the before-named compounds, and the fuming with ammonia is an additional aid. This can easily be proved by washing a small piece of unfumed sensitive paper, drying, and exposing under the negative. The print so obtained will be pale and flat, and the sensitiveness very much reduced.

Inasmuch as no one makes his own albumenized paper nowadays, it will not be worth while for us to enter upon the questions bearing upon this part of silver printing. We may say, however, that in earlier times a much larger quantity of chloride was deemed necessary in the albumen than at present. This, of course, required much stronger silver baths. We have seen formulæ calling for one hundred grains of silver to the ounce. At present forty-five grains (or perhaps fifty-five in winter) are considered ample.

The manufacturers of albumen paper have lately

adopted an excellent custom of sending out a formula for silvering solution and toning bath. Seeing that there are certain niceties in the relation of the quantity of chloride in the paper to the strength of the silver bath, and other details, which we need not enter upon at length, it will be better in almost all cases for the operator simply to follow the printed formula. Nevertheless, we may say a few words on the principal points to be observed.

As before stated, a bath containing forty-five grains of nitrate of silver to the ounce of water may be considered a fair strength, and we believe that almost all printers are now agreed that the solution should be faintly alkaline. It is quite true that with an acid bath good prints may be made, but the solution will be sure to turn red after a short time, while the alkaline bath will deposit the organic matters received from the paper in a few hours. The bath should not be exposed to white light, especially just after paper has been floated upon it. Alum in small amount we believe to be a most useful addition, from its strongly coagulating effect upon the albumen. A little alcohol also does no harm, but will aid both the coagulation and the rapid drying of the sheets when hung up.

The fuming of the paper requires some attention. In the first place, the paper must be perfectly dry. In the next place, the ammonia should be so managed that its fumes come off powerfully. The dish containing it should be warmed before pouring in. The mere evaporation of the ammonia will frequently make the vessel so cold that the fumes will not come off. A liberal amount of the liquid should be used, and care taken that it is of the highest commercial strength.

The object to be attained is to get the full action of the ammonia vapor on the dry silver surface. With proper arrangements, six to eight, or at most ten, minutes will suffice. But if the paper be damp, or a weak sample of ammonia be used, the prints will be sure to have a "sunk-in" appearance.

The routine of printing, washing, and toning, we believe, is well enough known not to require mention here.

We wish that the same could be said with regard to blisters. Probably no one of the various difficulties met with in the working of the art has attracted more attention. The theory at present seems to be that blisters are owing to an imperfect coagulation of that portion of the albumen film which lies directly upon the paper. When a sheet is floated, the coagulating action begins on the albumen surface, and gradually works its way into the paper. But we must not forget that the albumen film, having a great affinity for the silver salt, will act to a certain degree as a filter or strainer, so that it is doubtful whether the portion of fluid which penetrates to the paper is ever as highly charged with silver as that in the bath. Experiments made by totally immersing the sheet seem to prove that this theory is a true one, but any practical printer will see in a moment what an expensive and troublesome thing this would be to do in regular practice. If the paper were left longer on the bath in the hope of securing more perfect coagulation, we should be met by the same flat or "sunk-in" appearance to which we have before alluded. Excessive dryness of the paper before floating seems (as might be expected) to favor the formation of blisters, as also the use of very heavily albumenized samples.

Many remedies have been proposed for this trouble, perhaps the best being to pass each print from the fixing bath directly into a solution of common salt of about the same strength; then, after a few minutes' soaking, to turn a small stream of water on, so as to dilute the solution gradually. A wash of alcohol between toning and fixing has also been proposed. By others, again, an addition of ammonia to the fixing bath. This would increase the efficiency of the fixing solution. Then, common salt has been added directly to the hypo bath. But we believe that much may be effected by keeping the various wash waters and solutions at as nearly the same temperature as possible. In winter, for instance, all the various negatives, frames, paper, dishes, and a large jug or two of water, might be left near enough to the stove or heater to give them all a temperature of say 70°. In winter, also, it will be better to print under the skylight, or at least in a warm room. Paper if sensitized in a warm dark room, and then exposed to a freezing air during the printing, will often cockle up under the negative in a most refractory manner, and probably cause the loss of many prints. Cold weather will render the paper extremely dry, so that it will sometimes crack under the finger when bent, and is then in a most favorable condition for producing blisters.

The treatment of the ready sensitized papers is in the main just what we have recommended for the ordinary kind. If it does not tone readily by the formula accompanying it, we would advise a more thorough washing before toning, as well as a toning bath containing not less than a grain of gold to every four ounces of water, with just enough bicarbonate of soda to neutralize acidity.* Use litmus paper to make sure. Let the toning and fixing baths, however, under any circumstances be warm—not less than 80°—and wash the prints well between the two operations.

A DEVELOPER WITH SULPHITE OF AMMONIA.

I CALL attention to a new pyro developer with ammonia, and sulphate of ammonia, which has given splendid results with the ordinary commercial plates, equaling in every way negatives developed with ferrous oxalate, and even surpassing them.

The formula is:

A—Pyrogallic acid	10	parts.
Sulphite of ammonia	30	"
Water	100	"
B—Bromide of ammonium	5	"
Water	150	"

Immediately before use mix 100 parts of water with 4 parts of A and 4 parts of B. With this developer the image will appear quite rapidly. If it is desirable to prolong the developing process, 150 parts of water instead of 100 can be used. The negatives will be softer with a diluted developer, while more vigor, strength, and contrast is given by a few minims of a bromide of ammonium solution (1 to 10). Sulphite of ammonium developer makes brilliant and well-detailed matrices representing perfectly the whites and high lights. They are of an agreeable dark brownish color, far superior to that obtained by a glycerine or potash developer. The use of the alum bath before fixing is admissible but not necessary before fixing, but is wanted afterward. No acid is needed with the alum. Pyrogallol, mixed with a solution of sulphite of ammonia, is more durable than with sulphite of soda, and prevents fogging of the plate more effectually than the corresponding soda salt. Sulphite of ammonia should not be used in combination with either the carbonate of soda or of potash, with either of which carbonate of ammonia and the respective sulphites would be formed, resulting in but feeble action upon the bromide of silver emulsion, and rendering the negatives weak.—*Dr. J. M. Eder in Correspondenz.*

* This bath may be used an hour after mixing.

OPTICAL TELEGRAPHY.*

ALTHOUGH practically for a long time in disuse, optical telegraphy is none the less almost as old as the world. It was the first mode of communication and exchange of signals at a distance among primitive peoples. During the conquest of Algeria, fires were seen lighted upon the mountains and serving as rallying signals from the Gauls to the Kabyles. The marine has preserved these in the shape of lanterns and rockets, and railroads, with their colored lanterns, stationary or waved, merely practice optical telegraphy. The use of fires and lanterns supposes the telegraphing to be done at night, but we likewise have an example of optical transmission by day in the Chappe telegraph, which marked a great progress for its time, and in which semaphores slowly transmitted angular signals, interrupted by the fog.

When electrical telegraphy had disenthroned the Chappe system, there was a lull in optical transmissions, and it has been only in recent years that they have been thought of anew. The war in Tunis and that of Tonkin and China have proved what advantage can be gained by the use of this long-distance instrument. The military art has therefore taken it up, and it is certainly called upon to play an important role in future contests.

FIG. 1.—OPTICAL TELEGRAPHIC POST DURING THE SIEGE OF PARIS.

THE PRINCIPLE OF MILITARY OPTICAL TELEGRAPHY.

The principle of the optical telegraph may be formulated thus: The projection to a distance of a homogeneous fascicle of luminous rays, and the production in such fascicle, by means of a shutter, of alternate interruptions that correspond to the letters of the Morse alphabet. With a candle, any reflector whatever, and a cardboard box containing an aperture, any one can thus practice optical telegraphy in a room. With two Carcel lamps, carriage lamp reflectors, and a window shutter with a hole in it, proprietors of country seats might communicate at night between two pieces of property situated some distance apart. In military operations it is a question of great distances, and the communicating must be done in the day time as well as at night. The problem, then, is this: (1) to obtain an intense luminous source, and (2) to project a homogeneous fascicle therefrom in a given direction.

It is to Leseurre, an inspector of the French telegraph lines, and who died in 1864, that we owe the first optical telegraph that met such conditions. He employed solar rays reflected by means of an apparatus analogous to Gauss' heliotrope. The problem having been taken up again in 1870, has been more completely solved, as we shall see further along.

THE LUMINOUS SOURCE.

The luminous source may be (1) the sun, (2) the electric light, or (3) a kerosene lamp with a flat wick. For military telegraphy the first and third are the only ones of practical use. Our army telegraphers, with the dispatch with which they have to post themselves upon high summits, would not, as a usual thing, be able to drag along after them the heavy carriage necessitated by the electric machine that produces the light. As an offset, since electricity permits of obtaining luminous rays of great intensity, it will be able to render great services in the intercommunication of fixed posts—of fortresses, for example. The idea has also occurred to utilize it in semaphores placed upon the coasts, for the purpose of communicating with passing vessels.

PROJECTION OF THE LIGHT.

Whatever be the source that emits it, the luminous fascicle of the optical apparatus must be projected to the greatest distance possible. This is done by utilizing the properties of mirrors or lenses. There are different systems of optical apparatus in existence. Those used in military telegraphy are divided into telescopic apparatus with mirrors (stationary) and lens apparatus (portable), and are the result of the labors of Mr. Maurat, Col. Laussedat, and Col. Mangin.

FIG. 2.

TELESCOPIC APPARATUS.

Those properties of mirrors upon which an optical telescopic apparatus is founded are briefly as follows:

Concave Mirror.—Let MNM' (Fig. 2) be a concave

* From *Le Génie Civil.*

mirror, that is to say, one having a concave reflecting surface, and let C be the center of its curvature, situated upon the axis, x, y, and C M the radius of its curvature. If a fascicle of parallel luminous rays strike against M M,' the said rays will be reflected according to the law of the equality of the angles of incidence and reflection, and will meet at the principal focus, F, placed in such a way that CF=FN.

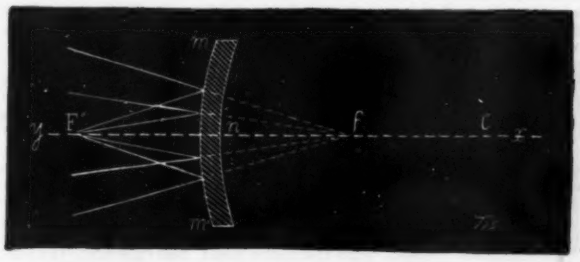


FIG. 3.

Convex Mirror.—Let us consider a spherical convex mirror, that is to say, one having a convex reflecting surface, *mm'*. The rays emitted by a luminous source placed at the point, F', will be reflected from *mm'*, and their hypothetical rectilinear prolongation will meet at a point, F, which is the virtual image of the point, F', upon the axis, xy (Fig. 3).

Combination of Concave and Convex Mirrors.—Let us now suppose that the point, F, coincides with the principal focus of a concave mirror, MM'. The latter, conformably to the principle indicated, will send the rays that come from A in a cylindrical fascicle parallel with the axis, xy.

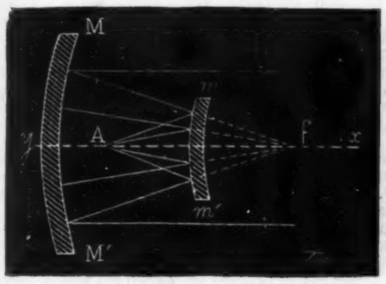
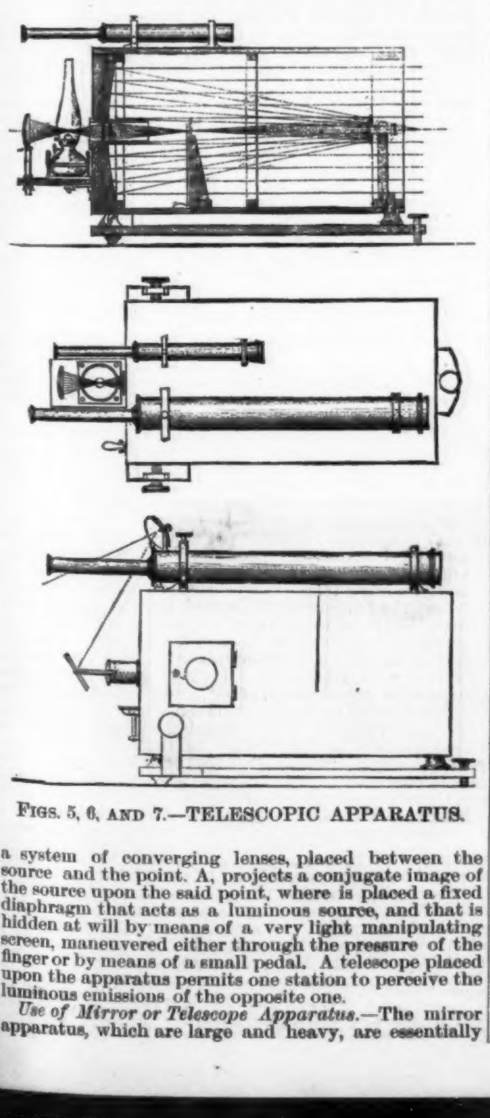


FIG. 4.

Such is the principle of the projector in the optical apparatus with mirrors. Through two mirrors, one concave and the other convex, placed a certain distance apart, it permits of taking up the rays emanating from a luminous source placed at A (Fig. 4), between the two mirrors, and reflecting them in a cylindrical fascicle parallel with the axis, xy.

In practice, the mirror, MM', has an aperture in the center. The luminous source is placed behind it, and a system of converging lenses, placed between the source and the point, A, projects a conjugate image of the source upon the said point, where is placed a fixed diaphragm that acts as a luminous source, and that is hidden at will by means of a very light manipulating screen, maneuvered either through the pressure of the finger or by means of a small pedal. A telescope placed upon the apparatus permits one station to perceive the luminous emissions of the opposite one.



FIGS. 5, 6, AND 7.—TELESCOPIC APPARATUS.

Use of Mirror or Telescope Apparatus.—The mirror apparatus, which are large and heavy, are essentially stationary. Ultimately they will give way to apparatus with lenses of large size, analogous to the campaign apparatus that we shall describe further along; and this substitution will have the excellent effect of unifying the apparatus.

However this may be, the optical apparatus with mirrors that now exist under the name of "telescopic," are founded upon the principle that we have just enunciated. It must be noted, however, that the large mirror, MM', at the end of the apparatus (Fig. 4), instead of being parabolic, as accurate calculation would indicate, is *aplanatic*, that is to say, formed of two spherical, non-concentric parts. It is thus more easily shaped than parabolic mirrors, and gives perceptibly the same results as the latter, as regards projection.

Range of Mirror Apparatus.—The annexed table shows the range of these apparatus according to their diameter:

Caliber of Apparatus. Inches.	Luminous Source. Sun during the Day. Kerosene at Night. Miles.	Kerosene during the Day. Miles.
13·5	30 to 36	7 to 9
17·5	48 to 54	12 to 15
23·5	60 to 72	15 to 18

It is rarely necessary to communicate to a distance of 72 miles. The large 23·5 inch apparatus, however, might in clear weather exceed that range.

CAMPAIGN APPARATUS WITH LENSES.

Let us recall those properties of lenses upon which the campaign optical apparatus is based.

Lenses.—Let MM' be a glass lens, and xy its optical axis. If we allow a fascicle of luminous rays to fall upon this lens parallel with its axis, it will, upon passing through the glass, be refracted and meet at a point, F, situated upon the optical axis, xy, and called the principal focus (Fig. 8).

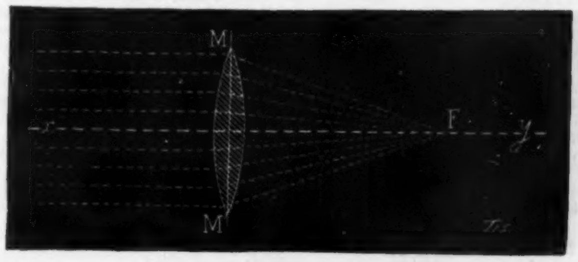


FIG. 8.

Conversely, when a luminous source emits a conical fascicle of diverging rays from the principal focus, F, these rays will be refracted by the lens parallel with the axis, xy, and, as a whole, will constitute a cylindrical fascicle parallel with the principal axis.

Use of Two Converging Lenses.—Let us now suppose (Fig. 9) that behind the lens, MM', there is placed another lens, NN', likewise convergent; then the luminous rays, doubly refracted, instead of converging at F upon the optical axis, xy, will converge at a new point, F', nearer the lenses. Upon adopting this arrangement, we shall be able, then, to place the luminous source of an optical apparatus at F' instead of at F, and diminish its length by so much—a matter of great importance in portable apparatus.

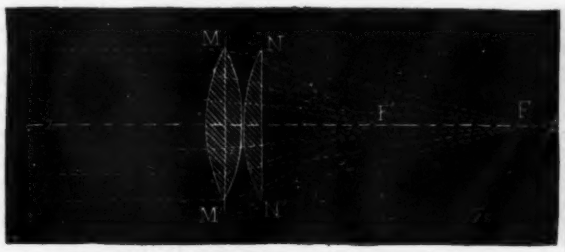


FIG. 9.

Luminous Sources used in Campaign Apparatus.—(Figs. 10 and 11.) The campaign apparatus consists of a simple or compound lens designed for projecting the luminous fascicles, and called the emission objective, and of a telescope serving for the reception of the signals.

The luminous source used is the sun during the day, and a flat-wick kerosene lamp at night. It is unnecessary to say that when the sun is not shining the lamp is used as a substitute—the light of this being distinguished very well, although not from so great a distance. When the sun is shining, its rays are concentrated into an optical fascicle by means of plane mirrors, or of a mirror apparatus moving automatically, and called a heliostat. This we shall describe further along.

Range of Campaign Apparatus.—These apparatus are classed according to the diameter of their emission objective in inches. We thus have 5·5, 9·25, 11·75, 15·5, and 19·5 inch apparatus.

Caliber in Inches.	Luminous Source. Sun during the Day. Kerosene at Night. Miles.	Kerosene during the Day. Miles.
5·5	18 to 24	4¾ to 6
9·25	27 to 30	8 to 9
11·75	33 to 39	10 to 12
15·5	60	12 to 18
19·5	72	18 to 24

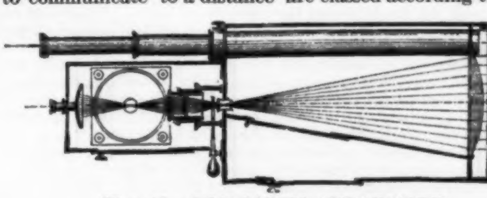


FIG. 10.—CAMPAIGN APPARATUS.

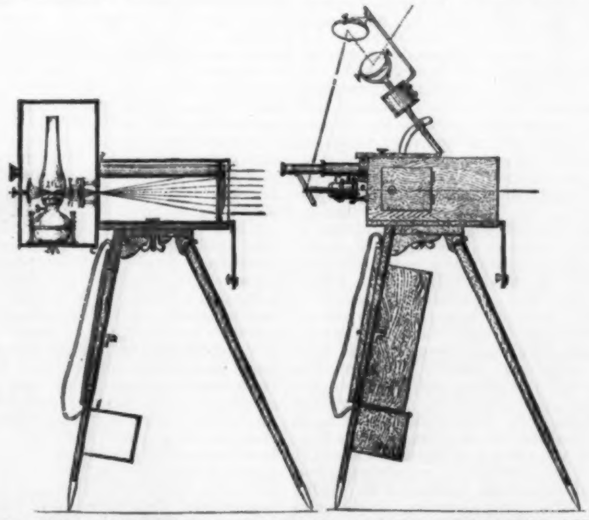


FIG. 11.—CAMPAIGN APPARATUS IN OPERATION (1) WITH KEROSENE AND (2) WITH SOLAR LIGHT.

DR. J. L. DAVIS says that in a case of common cold in the head he has used the following with complete success: Half a grain of tartar emetic is dissolved in four ounces of water, and a teaspoonful of this is given every fifteen minutes for four doses, and then hourly, and after that every three or four hours. The disease is often cured in the course of one day.—*Medical World.*

PAINTS FOR EXPOSED METAL SURFACES.

AFTER questions of form, strength, constructive material, and similar matters have been duly settled in connection with any engineering work made of wood or metal, writes Ernest Spon, the engineer has to consider the best method of maintaining that work in good condition. Apart from working casualties, the material of which the particular work is constructed is exposed to atmospheric and chemical influences which tend more or less to modify and corrode its surface, and an artificial surface is therefore formed by applying paint. Most of the paints used for ordinary work are composed of the coloring matter, then of a quantity of white lead, with which and a particular oil they are worked into a paste of the shade required, and are afterward trimmed down with oil and turpentine when used. The white lead which thus forms the basis of most paints, and is by itself a color, is the basic carbonate of lead, a heavy earthy powder, white when first made, but soon becoming of a gray tint when exposed to the air from the action of sulphureted hydrogen. It is insoluble in water and effervesces with hydrochloric acid, dissolving, when heated, as chloride of lead, which crystallizes in needles on cooling. Dilute nitric acid easily dissolves white lead, with effervescence caused by the escape of carbonic acid gas. When heated on a knife or slip of lead, it becomes yellow. It is not very generally known that white lead and oil combine with such energy that if linseed oil is poured upon a very large quantity of white lead, and the mass is allowed to stand for a few hours, the temperature becomes so high that the oil is carbonized and colors the whole a black. We should carefully avoid mixing with white lead substances which may impair its brightness or depreciate its other qualities, and it should be kept in closed vessels, otherwise it will acquire a brown shade. For good paint it should be pure and without foreign mixture; however, both manufacturers and painters add to it variable proportions of chalk, sulphate of lead, and the like, and it is often mixed with that sulphate of baryta which is called baryta white, and which is prepared from the native sulphate, or from carbonate of baryta artificially treated with sulphuric acid. Baryta white is an adulteration which ceases to be objectionable when the manufacturer makes the composition known, as it is of a handsome white color, entirely innocuous, fast, and resisting most reagents, its great defect being that it possesses but little body or covering power. The manufacturers sell various qualities of white lead, sometimes in powder or in lumps, as genuine dry white lead, or flake white, but the greater portion is a paste holding from 7 to 9 per cent. of oil. Krems, Nottingham, and Newcastle whites are pure lead, differing only in the way in which they are made. Venice white is a mixture of equal parts of white lead and sulphate of baryta. Hamburg, Holland, and other whites contain from 3 to 60 per cent. of sulphate of baryta, and inferior qualities large proportions of chalk. White lead paint is solid and durable, but the disagreeable vapors given off by the lead exercise a dangerous effect upon the health of the workmen who are engaged either upon its manufacture or use.

Many substitutes have been tried to obviate the employment of white lead. Zinc white in particular has received considerable attention; it has not such a bad effect upon the health, having no smell of itself, and does not impart any to the liquids with which it may be mixed, so that any place freshly painted with it may be at once inhabited without fear of its injuring the occupants. Zinc white is the oxide of zinc; it is insoluble in water, but dissolves in hydrochloric acid, usually effervescing slightly from the escape of carbonic acid, which oxide of zinc absorbs from the air. When heated, oxide of zinc becomes yellow, but resumes its white color in cooling. It is as brilliant, white, and fine as white lead, and becomes, on drying, so hard that it will take a bright polish; it does alter under the destructive action of sulphurous vapors, or of gas with equal weights; it covers a larger surface than carbonate of lead, but it is very dry under the brush, and therefore requires more labor in applying it, which to a great extent explains the disinclination to use it, in spite of all the efforts made in its favor. It also takes longer in drying, and when adulterated is very liable to change color.

Red lead, so largely used by engineers, is an oxide of lead usually in the form of bright red powder, which is affected by water, but evolves the smell of chlorine when boiled with hydrochloric acid, and is slowly converted into chloride of lead. Dilute nitric acid only partly dissolves it, leaving a brown powder. On account of its durability it is frequently used as a priming coat, often the only coat given on ironwork. Care should be taken that no salt is present, otherwise a chemical action commences, blisters are formed, and the lead is reduced to the metallic condition. It has been proposed to substitute for red lead a red obtained from a sulphide of antimony, termed antimony vermilion, which is sold in a state of very fine powder, without taste or smell, and which is insoluble in water, alcohol, or essential oils. It is but little acted on by acids, and foreign engineers state that when ground in oil it acquires great intensity or brightness of color, that it has a good body, is unalterable by air or light, and may be freely mixed with white lead. Black paints made from the residual products obtained in distilling coal and shale oils are largely employed for rough work. They combine readily with drying oils, and give an intense and handsome black, which is at the same time very economical. Native oxide of iron has of late years supplied us with a paint which possesses many of the good qualities of red lead without its inconveniences. Oxide of iron paints are most effective and durable paints to use on iron, as they have no tendency to change or affect the surface of the metal. An analysis of one of these paints gave peroxide of iron, 68·95; aluminous earth (clay), 1·48; burnt clay, 29·57; total, 100. The purple-brown oxide is a hydrated peroxide of iron. Grant's black is made of shale containing oxide of iron, and the well-known Torbay paint is a protoxide of iron. Under equal volumes iron paints cover more than those from lead; mixed with one-third of white lead it forms an excellent mastic, similar to that made from red lead, and which becomes very hard after drying for some time. As the iron-oxide paint resists a strong heat, it is advantageously employed for painting parts of machines and boilers. The so-called anti-corrosive paint is made of equal parts by weight of whiting and white lead, with half the quantity of very fine sand or road dust, with colors at pleasure. The mixture being made with water can be used as a water color, but it is usually applied as an oil paint. The preparation of oil recommended for this purpose is 12 parts by weight of linseed oil, raw, one part of boiled linseed oil, and three parts of sulphate of lime, the whole well mixed. One gallon of oil thus prepared is used to 7 pounds of the paint. Paints containing silica have been used for both wood and paint; they give a hard substance which is very durable; it is stated that when mixed with proper oils they will resist the action of salt water or acids better than iron or lead paints, that they cover well, and that in the case of wood they form a considerable protection against fire. In addition to the pigments mentioned, which are in themselves colors, various tints are produced by the addition of ochers, earth naturally covered by iron; chromes or yellows, consisting of oxide of lead and chromic acid; blues such as Prussian blue, from animal refuse burnt with potash and iron; smalts from oxide of cobalt; ultramarine blue, from carbonate of soda, silica, alum, and sulphur; or greens, from oxides, carbonates, and arsenates of copper.

The oils employed in engineering painting are linseed oil, nut oil, and poppy oil, which, in common with a few other vegetable oils and resinous matters, possess the property of drying, after being placed upon the surface of a substance, into a resinous compound. Of these oils linseed is by far the most important, and its characteristics deserve careful study, as it alone has pre-eminently the valuable qualities of great strength and flexibility. It is by far the strongest oil, and the one that dries best and firmest. It has also great body, resists the inclemencies of the weather well, and is least affected by the atmosphere. Good linseed oil is of a pale, transparent amber color, very limpid, with little smell, and comparatively sweet to the taste; it is specifically lighter than impure oil, and dries quickly and firmly. This oil is more viscous or glutinous than other oils, and can be easily recognized by its peculiar odor and taste. Linseed oil improves greatly in quality by age, and ought to be kept at least six months after it has been expressed before being used. A strong drying quality can be given to the oil by boiling it either with or without the addition of other substances. The substances thus added are very various, the principal being litharge, acetate or sugar of lead, red lead, and oxide of manganese—the last named when the body of the paint is to be zinc white. The most simple method of preparing oil is by boiling it for a considerable time without any addition, and drying oil can be prepared for common work by mixing 1½ pounds of red lead with 1 gallon of linseed oil, boiling them together, and afterward letting the oil stand for a few days for the lead to sink to the bottom. A considerable drying quality may be given to linseed oil and the color much improved, without its being boiled, by mixing about 1 pound of white lead to 1 gallon of oil, and letting it stand a week or two until the lead and feculent parts of the oil have sunk to the bottom of the vessel in which the oil is placed. This is likewise a cheap way of purifying oil, as the lead can always be used for common purposes. Other things being equal, the most essential quality to be required in oils is their drying well, which, although it may be assisted by additions, is yet to be observed in the oil itself, as the effect of some pigments is sometimes such as to counteract the strongest driers, and occasion great trouble and delay from the work remaining wet a considerable length of time. Nut oil is more uncertain in its qualities than either linseed or poppy oil, and is frequently a long time drying. When of good quality it is very limpid, of agreeable taste, sweet smelling, and free from rancidity or sediment. Poppy oil is extracted by pressure from the seeds of the plant, and should be white or very light yellow in color, sweet and without smell. Both nut and poppy are far inferior in strength, tenacity, and drying qualities to linseed, but have the reputation of keeping color better, and are on this account sometimes employed in interior work for thinning paints used for ornamental purposes and which require to be very white or carefully executed. Driers for hastening the drying of colors are very much used in addition to the drying oils. Those most approved are sugar of lead and litharge. These, when ground and mixed in small quantities with paints, very much assist them in drying; indeed, some colors will not dry without them. Red lead is also an excellent drier, and in cases where its color is not objectionable is much employed. Sugar of lead is, however, the best drier, though somewhat more expensive than the others. In the last or finishing coats of light colors, driers are generally avoided, as they have a tendency to injure the color. The spirits of turpentine for thinning the colors should be of good quality, which may be ascertained by weighing equal quantities and comparing the weights, the lightest being the best. The goodness of spirits of turpentine may likewise be ascertained by noticing the degree of inflammability it possesses; the most inflammable is to be preferred. Those who are much in the habit of using "turps," as they are familiarly called, will tell by the smell their good or bad qualities, for good turpentine has a pungent smell, the bad a very disagreeable one and not so powerful. Painting, when properly executed, will not present a shining, smooth, and glossy appearance, as if it formed a film or skin, but will show a fine and regular grain, as if the surface were natural or had received a mere stain without destroying the texture. For woodwork, before the paint is applied the surface must be free from moisture of any kind, and seasoned. Dampness, moisture, or unseasoned substances in woods, stopped in or covered over with paint, will in all probability tend to their destruction. The surface is then free from anything which may prevent the paint from becoming identified with the material. Thus, in painting pine woods of any kind, the rosin contained in the knots which appear on the surface must be neutralized, or a blemish will show on every knot; this is done by killing the knots with two or more coats of red lead ground with water and mixed with size; a preparation known as "patent knotting" is also very much used. It is composed of shellac, naphtha, and some other drying agent. The heads of nails having been carefully punched in, all nail holes, cracks, or other defects are stopped and filled up with putty or wood. The surface of the wood is then rubbed smooth with sandpaper or pumice-stone. The number of coats usually given to new woodwork is four. The first or priming coat need have very little, if any, of the final coloring matter in it. After priming, all nail holes or other superficial defects are carefully stopped up before the next coat is applied. The coats are laid on as the previous coats become dry, which is generally in about 48 hours. The paint requires renewing after every two or three years, when but two coats are usually required. For fine work each coat is rubbed with pumice or sandpaper and well dusted before the next is added.

In repainting old work all dirt is carefully removed with the stopping knife and duster; those places that are rough are rubbed with pumice-stone, and greasy marks cleared off with turpentine. New patches and decayed parts are then brought forward with a coat of priming, all defects stopped and made good with putty, and the first coat or second color proceeded with in turpentine. The quality of the next coat will entirely depend upon the manner in which it is to be finished. If it is to be painted twice in oil and flatted, the next coat or third color should be mixed up chiefly in oil and tinted, like the finishing color, to form a ground for flatting. The greater the shine of the ground, the more dead will the finishing coat or flatting be; likewise the more dead the ground, the better will the finishing coat shine; therefore it is the general rule that for finishing in oil the undercoat should be turpentine, and for finishing flat the undercoat or ground color should be oil; but it is to be observed that all turpentine undercoats have a little oil with them, and all oil undercoats except the priming or first coat on new work have a little turpentine with them. When ironwork has to be painted, the engineer has a very different task to perform. Cast and wrought iron behave very differently under atmospheric influences, and therefore require somewhat different treatment. The decay of iron becomes very marked in certain situations, and weakens the metal in direct proportion to the depth to which it has penetrated, and, although where the metal is in quantity this is not very appreciable, it really becomes so when the metal is under three-fourths inch in thickness. The natural surface of cast iron is very much harder than the interior, occasioned, no doubt, by its becoming chilled or by its containing a large quantity of silica, and affords an excellent protection, but should this surface be at all broken, rust immediately attacks the metal and soon destroys it. It is very desirable that the casting be protected as soon after it leaves the mould as possible, and a priming coat of paint or oil should be applied for this purpose; the other coats thought requisite can be given at leisure.

The following is the process to which all water-pipes should be submitted. It was introduced by Dr. Smith, and is equally applicable to any other kind of casting that can be maintained: Each casting is thoroughly dressed and made clean and free from earth or sand which clings to the iron in the moulds, hard brushes being used in finishing the process to remove the loose dust. Every casting must be likewise free from rust when the paint is applied. If the casting cannot be dipped presently after being cleansed, the surface must be oiled with linseed oil to preserve it until it is ready to be dipped; no casting is on any account to be dipped after rust has set in. The coal-tar pitch used as a paint in this process is made from coal-tar distilled until the naphtha is entirely removed and the material deodorized. In England it is distilled until the pitch is about the consistence of wax. The mixture of 5 or 6 per cent. of linseed oil is recommended by Dr. Smith. Pitch which becomes hard and brittle when cold will not answer for this use. Pitch of the proper quality having been obtained, it must be carefully heated in a suitable vessel at a temperature of 300° F., and must be obtained at not less than this temperature during the time of dipping. The material will thicken and deteriorate after a number of pieces have been dipped; fresh pitch must therefore be frequently added, and occasionally the vessel must be entirely emptied of its old contents and refilled with fresh pitch. The refuse will be hard and brittle like common pitch, and, consequently, worthless for the purpose. Every casting must attain a temperature of 300° F. before being removed from the vessel of hot pitch. It may then be slowly removed and laid upon skids to drip. In the case of water-pipes, all those of 20 inches diameter and upward will have to remain at least 30 minutes in the hot fluid to attain this temperature. The coating, when cold, should be tough and tenacious, and not brittle, nor have the slightest tendency to scale off.

In considering the painting of wrought iron, it must be noticed that when iron is oxidized by heating in contact with the atmosphere, two or three distinct layers of scale form on the surface, and, unlike the skin upon cast iron, can be readily detached, as by bending or hammering the metal. The outer layer of this scale is more highly oxidized than the inner, and is slightly redder in tinge from the presence of a variable excess of ferric oxide over that contained in the inner layer. The oxide occurring in the outer scale is fusible only at a high temperature, is strongly magnetic, and slightly metallic in luster, while the inner layers are more porous, dull and non-metallic in luster, less brittle, and also less powerfully magnetic. It will be seen that the iron has a tendencey to rust from the moment it leaves the hammer or rolls, and that the scale above described must come away. One of the plans to preserve the iron has been to coat it with paint when still hot at the mill; and, although this answers for a while, it is a very troublesome method which ironmasters cannot be persuaded to adopt, and the subsequent cutting processes to which it is submitted leave many parts of the iron bare. Besides, a good deal of the scale remains, and until this has fallen off or been removed any painting over it will be of little value. The only effectual way of preparing wrought iron is to effect a thorough and chemical cleansing of the surface of the metal upon which the paint is to be applied, that is, it must be immersed for three or four hours in water containing from 1 to 2 per cent. of sulphuric acid. The metal is afterward rinsed in cold water, and, if necessary, scoured with sand, put again into the acid bath or pickle and then well rinsed. If it is desired to keep iron already cleansed for a short time before painting, it is necessary to preserve it in a liquor rendered alkaline by caustic lime, potash soda, or their carbonates. Treatment with caustic lime-water is, however, the cheapest and most easy method, and iron which has remained in it for some hours will not rust by a slight exposure to a damp atmosphere. Although desirable,

this method of cleansing the surface is impracticable in the majority of cases, and recourse must be had to scrapers and hard brushes to remove the scale of rust. Having obtained a clean surface, the question arises, What paint should be used upon iron? Bituminous paints, as well as those containing variable quantities of lead, were formerly considered as solely available, but their failure was made painfully apparent when the structures to which they were applied happened to be of magnitude, subjected to great inclemency of weather or to constant vibration. Recourse has therefore been had to iron oxide itself, and with very satisfactory results. Iron oxide paints are made of two qualities. The first quality is the best adapted for ironwork, and is made by purifying the oxides and placing them in retorts, when the various colors are mixed with them. They are altogether submitted to seven distinct processes in the course of manufacture. To insure large surfacing qualities, or the power of covering a large area with a small quantity of paint, the ingredients should be reduced to an impalpable powder before they are mixed with the oil, and after mixture in first quality they are ground for seven or eight hours. The second quality have their colors chemically combined by mixture, and are not so carefully prepared, although they are excellent for common work. A pound of iron oxide paint, when mixed ready for use in the proportions of two-thirds oxide to one-third linseed oil, with careful work, should cover 21 square yards of sheet iron, which is more than is obtained with lead compound. Oxide of iron paint endures a very great heat without material alteration, and keeps both its color and preservative qualities well. The author is of the opinion that, when used under proper supervision, no better protection can be found for iron structures than oxide or iron paints. There is this difference to be noticed between painting of iron and wood—that with the former, when a painter comes to spots of rust that cannot be removed, he should endeavor to incorporate them with the paint rather than paint over them. The repainting of iron involves carefully washing down and removing all dust, dirt, and so on, from the entire surface, every particle of rust being scraped and chipped off, the work receiving from two to four coats in oil, properly applied. The author would observe, in conclusion, that the real value of any paint depends upon the quality of linseed oil, the quality and character of the pigment, and the care bestowed on grinding and mixing, and, as all this is entirely a matter of expense, cheap paints are not to be relied upon. He is convinced that the superiority of most esteemed paints is due to the above causes rather than to any unknown process or material employed in the manufacture, and their comparatively high price corroborates this opinion.

THE CASTING OF THE BARTHOLDI STATUE OF LIBERTY.

M. BARTHOLDI, in an account which he has himself written of the casting of the gigantic statue of Liberty, gives many interesting details of the process by which the work was executed. The system of hammered copper was adopted because of its artistic elements of excellence, and also because it allowed of a large subdivision in the pieces, thus rendering transportation easy. The total height of the first model was only 1·25 meters. This was the study model, which was long sought and often recast. This model was afterward reproduced in terra-cotta to the number of 200 copies. From this study was made a statue measuring 2·85 meters. This was executed with rigid precision, and reproduced four times as large by the ordinary process. The model which was the result of this work measured about 11 meters in total height. This statue was divided into a large number of sections, destined to be produced separately at four times their size After this last enlargement changes were no longer possible. The work of reproduction was carried on in an immense workshop specially constructed for the purpose. There were four plane surfaces, encompassed with frames, laid out in numbered divisions. Another similar frame, corresponding exactly to the one below, was fastened beneath the ceiling of the workshop. Lead wires and rulers hung all around the frames. On these frames, thus geometrically laid out, the sculptors executed in wood and in plaster enormous fragments of the statue. The sections of the model that they were to reproduce were arranged near by under corresponding conditions, between frames of one-fourth the size. The sculptors executed the enlargements by measurements taken with the compasses on the lead wires and the rulers. They first laid out the general form with wooden beams covered with lath work. The wood was then covered with a coating of plaster. They verified the large measurements already established, and then executed the reproduction point by point, and finished the modeling of the surfaces. Each nail-head and point marked required six measurements, three on the model and three for the enlargement, without counting the verifying measurements. There were in each course about 300 large points and more than 1,200 secondary points, which represented for each course the work of establishing about 9,000 measurements. Wooden moulds were made of each course, and into these moulds the hammerers pressed the sheets of copper. The pieces of copper were finished by beating them with little hammers and with rammers. The profile of the forms was again taken in detail with sheets of lead, pressed upon the model, again working the copper according to the profiles. The pieces of copper were furnished from point to point with iron braces, intended to give them rigidity. These braces were forged in the form of the copper when the contour of the latter was completely modeled. Thus furnished, the pieces were carried to the mounting in the court, to be brought together and fastened on the powerful truss-work of iron-beams which served as support for the whole envelope of the statue. The core of this truss-work was formed by a sort of pylon, which had four points of attachment. Each of these points were sustained by three bolted braces, 15 centimeters in diameter, which were made fast at a depth of eight meters in the masonry of the foundation to a frame of iron beams. This truss-work served as a support for the copper form of the statue. The copper plates, kept in shape by iron bands, were supported by iron braces, which were cramped on to the central core. Their weight was always independent of all that was above and below. Exhaustive mathematical calculations were made upon the resisting power of the iron pieces, upon the center of gravity, and upon the action of high winds. These calculations were made by taking as a base the most powerful hurricanes which have ever been recorded, either in America or in Europe. This gigantic statue, which far exceeds in size all statues of ancient and modern times, is constructed of copper sheets two and a half millimeters in thickness. It measures 46·08 meters from the base to the top of the torch, 35·50 meters from below the plinth to the crown, 34 meters from the heel to the top of the head. The forefinger is 2·45 meters in length, and the head is 4·40 meters in height. The nose is 1·12 meters in length. About 40 persons were accommodated in the head at the Paris Exhibition of 1878. It is possible to ascend into the torch above the hand. It will easily hold twelve persons. The total weight is about 200,000 kilos, of which 80,000 are copper and 120,000 iron. The statue represents an outlay of more than 1,000,000 f., including gifts, gratuitous work, and the losses of all those who gave their praiseworthy assistance to the work.

FIG. 3.—HAMMERING A PLATE OF COPPER INTO A PATTERN.

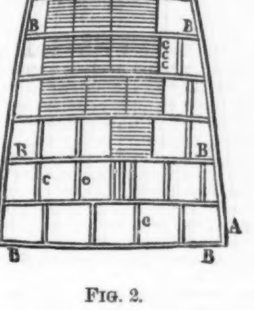


FIG. 2.

FIG. 4.

FIG. 1.—WOODEN SKELETON OF THE LEFT HAND.

VALUES OF LUBRICANTS.

By ROBERT H. THURSTON.*

A SYSTEM of collection and purification of the oil running off the ordinary journals into the drip pans may, in nearly all cases, be easily adopted, at once reducing the cost of lubricant and making its first cost a matter of still less consequence.

Suppose a grease used in the shop under consideration, and such as now costs twenty-five cents per pound, and assume that it is given as a sample, costing the proprietor nothing, but bringing up the coefficient of friction, as an average, to 0·10. The cost of power is now the total expense, and this becomes $3.33 per hour, or $10,000 per annum, while the loss to the owners of the establishment on their bargain is $5,000 per annum.

It will next be asked, What price represents the limit which may not be exceeded, without loss, in the purchase of the oils proposed to be substituted for that first

* From a paper by Prof. R. H. Thurston, Director of Sibley College, Cornell University.

used in this instance? By a proper equation we find the second oil causes a loss of $10.78 for every gallon used, and hence cannot be used without loss, unless the user is paid that sum to take it and apply to his machinery. Comparing the first two cases named in last week's article, it is found that the second disposition of the poorer grade of oil is of such advantage that it is as well worth eighty-four cents per gallon as is the better oil worth fifty cents, used as at first proposed. But it would be a still better investment to purchase the better oil. Comparing the first and last cases, using equal amounts per gallon, the equation shows the heavier lubricant as subjecting the user to an expense amounting to over $10 for every pound used. It must not, however, be inferred from this that it is always wasteful to use the greases. They are often advantageous where exceptional pressures are used, or troublesome bearings are met with, and are sometimes absolutely indispensable, saving large amounts by their reduction of expense in the cooling and preservation of journals, and in the renewal of bearings.

As a second illustration, assume a cotton mill to use a good oil, averaging seventy cents per gallon, at the rate of 0·7 gallon per hour, with a mean coefficiency of friction 0·10, on machinery demanding 400 horse power, of which 120 horse power is required to overcome the friction of surfaces lubricated by the oil. Taking the value of the power at $65 per horse power per annum, and 3,000 working hours, we have one element of the equation. If it is proposed to substitute for the oils used in this mill others averaging a cost of forty cents per gallon, giving a mean coefficient of friction of 0·12, and of which one gallon will be used per hour, and a proper equation shows a gain of nine cents per hour, or $270 per annum, in buying oil, which is to be set against a loss of fifty-two cents per hour, or $1,560 per year, in increased expense on the account of operating mill, the net loss amounting to above $1,000 per year. Had the coefficient of friction been increased to a greater extent, the loss would have been correspondingly greater. The differences among the lubricants sold for mill purposes in the market are sometimes enormously greater than assumed above, and a loss of $10 per horse power annually is probably not an unknown case, and this is equivalent to about double that sum per horse power expended on the friction simply.

Thus the owner of a mill could not afford to accept the second lubricant in substitution for the better oil as a gift. The substitution of an engine oil on the spindles for the best spindle oil might readily double the expenditure of power absorbed by the spinning machinery, and thus increase the cost of both lubrication and power, the former having both a higher coefficient of friction and greater price than the latter.

The conclusions to be drawn from the principles and theory which have been presented in last week's issue and in this, and from the examples of application to practice which have been introduced, are obvious and definite:

1. To secure the highest possible efficiency of machinery and maximum economy in the operation of establishments in which it is employed, lubricants must be very carefully selected with reference to the precise conditions as to pressure and velocity of rubbing met with in the individual case. Where, as in machine shops and mills for example, there exist great differences in these respects, it will be found best to use different oils, as heavy oils on the engine-bearings, special cylinder oils in the steam cylinder, lighter oils on the shafting, and the lightest of the better class of lubricating oils on light machinery, as on spindles.

2. Differences in price of oils or other lubricants are usually of exceedingly slight importance in comparison with differences in costs of power, and the value of the coefficient of friction is therefore of vastly greater consequence than either the price of the lubricant or its endurance.

3. The best oils for specified purposes should be taken as a rule, whatever their market price; while the oils which are not well adapted to the purpose in view cannot be economically purchased at any price. It will often be found that the best quality of oil is not necessarily the best oil for any one specified purpose. An oil may be intrinsically excellent, and may be a very expensive oil, but may, nevertheless, be absolutely worthless for the purpose in view. A good engine oil would, for example, be quite unfitted for use as a spindle oil, and though several times as high in price, might be the cause of such considerable waste of power on light mill machinery that the millowner, as has already been seen, might find it to his interest to decline using it, even if it were offered him as a gift. The heavy oils are the most costly, and in this case the better oil is, therefore, also the cheaper in the market.

4. The cost of using a lubricant which is not well adapted to the work is so great that unguents should always be tested, and their adaptability to the special case determined, by a correct system of chemical and physical tests, and by trial upon a good testing machine, if possible, under the exact conditions of the intended use. The determination of the quality of any lubricant is an easy task; but the identification of the real conditions of use, as proposed, may sometimes be difficult. The difficulty arises, however, not from faults of method of test or uncertainty of results, but from defects of design or construction, or sometimes of management, of the machinery upon which it is proposed to use the oil. Where journals are kept in good order, and are properly proportioned, no difficulty need ever arise in the attempt to find the best possible lubricant for them. As a rule, there is no excuse for a condition of machinery which gives rise to such uncertainties. As a rule, in all successfully conducted departments of business, such uncertainties do not exist; they do not arise with sufficient frequency to invalidate the above rules. Testing machines are now made in sufficient variety of form and of ample range of application, and of such satisfactory accuracy that there is no longer necessity of accepting the risks, and of meeting the enormous expense involved in the application of lubricants of unknown quality to valuable machinery.

5. Where lubricants of the precise quality desired are not found in the market, it is advisable to secure the right grade by mixing. This can always be done by making a series of mixtures of good oils, such that, at the one side, the gravity and other qualities shall be too high, and, on the other side, too low, for the special application had in view, and thus working out—after determining by trial the law of variation—the mixture must prove suited to the purpose. The assayist has often been called upon thus to determine the best of a series of mixtures for a cylinder oil, for example, or for an engine or a spindle oil. By this method the quality of the oil has sometimes been improved for a special kind of work more than one hundred per cent. Satisfactory results can almost invariably be obtained by careful and skillful work.

THE DETERMINATION OF TANNIC ACID IN TANNING MATERIALS.

By NELSON H. DARTON.

IN an article published in this journal two years ago,* I have given the results of a detailed series of investigations upon the "Relative Values of the Various Methods of Tannic Acid Determination," wherein it was proved that for many tanning materials the most satisfactory process was one which I outlined before the American Chemical Society, in the same year.† An extended experience in the interval having justified my assertions as to the probable value of the process, a description of its details will doubtless be of value to many.

In my own laboratory over a thousand analyses have been made by the process for the trade, and in every instance satisfactory, and it has found extended use in many American laboratories, and met with much favor where in use abroad. It is simple in manipulation, and after a little practice almost any one can succeed with it. The apparatus required is simple, and comparatively inexpensive, and the results are obtained without delay by an almost continuous process.

Its greatest accuracy is in the assay of hemlock, oak, birch, and similar barks, sumac and galls, while with some wood extracts, cutch, kino, and similar gummy matters, it has to be considerably modified to yield satisfactory results.

By a continuation of the process on a similar principle, gallic acid may be determined in the same sample, and the importance of this acid in the tanning process is now well understood.

For the determination of the tannic and gallic acids remaining in spent barks and liquors, the process is well adapted, and has yielded most satisfactory results.

The advantages of the process over the many others is discussed at length in the paper cited above. At that time, however, the improved modification of Lowenthal's method by Proctor was not suggested, and subsequent comparisons of this with my process by myself and by its author have convinced me of its great value for many determinations, for which, as before noted, my process is not so well adapted. The apparatus required for the execution of the process is as follows:

A Balance and Weights.—One of Becker's sugar balances will answer; those with a glass case are preferable, and cost about twenty-five dollars; a set of gramme weights, from a fifty gramme piece down to five milligrammes, is also required, and a few hints upon the proper use of a balance will be of value to some. A balance should be placed upon a firm shelf or table in a place as free from dust as possible, and carefully leveled by means of the leveling screws under two corners of the balance case. The weights should always be moved by the pincettes accompanying them. In weighing, the substance or weights must not be placed directly upon the scale pans, but in the accompanying counterpoised watchglasses; it will also be found much less confusing to try the weights in their order rather than at haphazard. Nothing should be added to or removed from the balance while it is suspended, as this would soon injure its working, and its beam should be lowered before making any alterations in the contents of the glasses in the pans. A balance, if properly kept, will last many years, and may always be relied upon, while a poor balance is but little better than none.

A Liter Flask.—One with a ground glass stopper is preferable, and in measuring with it, care should be taken to have the temperature of the solution quite nearly 60 degrees F.; also a 100 c. c. flask, and a couple of pint flasks, several of about a half pint, and a few smaller ones, are necessary.

Burette.—A 50 c. c. burette accurately divided into $\frac{1}{10}$ c. c. As this is to hold a very corrosive solution, it cannot be the form in general use, and I have had the most success with the form proposed by me some years ago,‡ consisting of an ordinary burette drawn to a fine orifice below, and tightly stoppered above by a rubber cork, through which passes a slender glass tube connected with a yard of small rubber tubing, near the other extremity of which are two powerful pinchcocks three or four inches apart. A stand and pair of clamps are necessary to hold it upright.

Pipettes.—Three 25 c. c. and one 10 c. c. capacity. Besides these a couple of 4 inch glass funnels, and a stand to hold them; several beakers of about 100 c. c. capacity; an iron tripod and 6 inch copper waterbath, with a Bunsen burner and rubber tubing if gas is at hand, or an alcohol lamp if not, complete the apparatus. Several quart glass stoppered bottles should be provided for holding the solutions.

The chemicals required are an ounce of pure permanganate of potassa, two ounces of c. p. sulphate of copper, a pint of stronger water of ammonia, two ounces of artificial indigo of the best quality (sulphindilate of potassium), a half pound of pure sulphuric acid, a package of Swedish filter paper (five inch), and a half dozen weighed portions of absolutely pure sublimed oxalic acid, each representing two-tenth gramme of tannic acid ($C_{14}H_{10}O_9$); this is just 0·3007 gramme, and may be obtained from many of our fine chemical dealers, in small tubes.

Preparation of the standard solutions is the next step, and its details must be carefully carried out if accurate results are expected.

The Permanganate of Potass.—About three grammes of crystals are weighed out, and dissolved in a small portion of boiling water; when cool, the bulk of the solution is made up to one liter, and preserved in a dark glass stoppered bottle.

The Indigo Solution.—About a gramme of the artificial indigo is dissolved in a few ounces of boiling water, its volume made up to about a liter, and preserved in a dark colored bottle, preferably glass stoppered.

The relation of these two solutions to each other must now be determined. The burette is filled with permanganate solution by suction. Twenty-five cubic centimeters of the indigo solution is measured out into a half-pink flask, to which are added ten cubic centimeters of dilute sulphuric acid* and sufficient water to half fill the flask, which is then placed on a sheet of white paper under the burette; the permanganate solution is run into the contents of the flask, a cubic centimeter at a time at first, by opening both pinch cocks each time until about 10 cubic centimeters have been added, when it is run in drop by drop by alternately opening the pinchcocks. At first the color remains unchanged, but finally lightens, passing through pea-green to nearly white, when a drop or two more changes it to a bright orange tint, which deepens in intensity on further additions. If the exact point in change was struck, read off the volume of solution used; if not, repeat the operation until a satisfactory end reaction is noted. Some practice may be necessary in order to become accustomed to this titration.

One of the tubes of oxalic acid is then taken and emptied into the 100 cubic centimeter flask, carefully avoiding the loss of the smallest particle. The flask is then half filled with water, and when all is in solution, it is filled up to the mark, and its contents thoroughly mixed together by shaking. Twenty-five cubic centimeters is then measured and run into a flask as in the first titration. The same quantity of indigo solution and sulphuric acid and sufficient water being added, the titration is conducted as before, and the amount of solution used carefully noted to the $\frac{1}{10}$ c. c.; from this is deducted that necessary for the 25 c. c. of indigo solution alone, as determined in the first titration. If the strengths of the solutions are properly relationed to each other, the indigo will have required about 25 c. c. of the permanganate solution, and the oxalic acid about 15 c. c. If the indigo solution has required more than 2 c. c. less of the permanganate than above noted, more of the indigo should be dissolved in it by the aid of heat, and the strength again tried. When all is right, the relations of the solutions are noted on their labels, and we are ready to proceed to the analysis (the portion of oxalic acid solution remaining may be thrown away).

The average amount of tannic acid in hemlock, oak, and similar barks is about eight per cent., and a liter of decoction from twenty grammes of these materials will be of the proper strength for the most satisfactory titration. In spent barks the percentage of tannic acid is seldom over two, and sixty grammes of the material should be used. Sweet tanning liquors prepared from bark contain about 1¼ per cent., and seventy-five grammes of this is necessary; while with spent liquors, which contain from ¼ to ½ per cent. of tannic acid, at least 200 grammes should be taken; with bark extracts which contain from 20 to 25 per cent., five grammes to a liter will be sufficient, and other materials of greater or less strength in proportion to their tannic acid.

The preparation of the decoctions from these materials requires considerable care to prevent decomposition. The liquors and extracts need only to be weighed out in a counterpoised beaker glass, and transferred to the liter flask by repeated mixings with cold or—if necessary—warm water, which has either been distilled or is very soft.

The barks are coarsely powdered and weighed out in a beaker, from which they are carefully transferred to a capacious flask, covered with pure cold water, and, if convenient, set aside for an hour and frequently shaken; the supernatant liquor is poured off into the liter flask, more water is added to the bark, and it is placed upon the waterbath, the neck of the flask being *loosely* stoppered with a cork. Heat is then applied and the bath kept boiling for half an hour, replacing the water as it evaporates. The decoction thus obtained is transferred to the liter flask holding the first portion, and this operation is repeated. The volume of decoction is then made up nearly to a liter, twenty-five cubic centimeters of the dilute sulphuric acid is added, and the whole is carefully filtered, and the filter rinsed with a small amount of water; sufficient ammonia solution is added to the filtrates to impart a slight odor of the gas, and if any turbidity is produced, the filtering must be repeated. Finally, twenty-five cubic centimeters more of the acid is added, and the decoction made up to a liter is ready for analysis.

The solution of liquors or extracts is similarly treated with acid and ammonia.

A solution of sulphate of copper should now be prepared by dissolving two ounces of the pure salt in a pint of water; to this is added sufficient stronger ammonia solution to redissolve the precipitate at first formed. A deep azure blue solution is obtained, having a strong odor of ammonia. This mixture may be preserved in a glass stoppered bottle.

Twenty-five cubic centimeters of the decoction or solution is measured out into a half-pint flask, and to it is added 25 cubic centimeters of indigo solution, 10 cubic centimeters of sulphuric acid solution, and sufficient water to half fill the flask. This mixture is titrated with the permanganate solution exactly as previously described for the oxalic acid, great care being taken to note the end reaction very precisely. One hundred cubic centimeters of the decoction is then measured into a half-pint flask, and 100 cubic centimeters of a mixture of about one part copper solution and three parts water added to it. The mixture is thoroughly agitated and poured upon a filter; the first 50 cubic centimeters of filtrate is rejected, and the succeeding 50 cubic centimeters collected in a half-pint flask; to this is added 25 cubic centimeters of the acid solution, 25 cubic centimeters indigo solution, and the flask is half filled with water. The titration with permanganate solution is again repeated, and the amount of permanganate solution used, less that necessary for 25 cubic centimeters of indigo solution, gives the amount consumed by matters other than tannic acid (which has been removed by the copper solution), and which was included in the first titration; consequently this last result is subtracted from the first (from which the number of cubic centimeters necessary for the indigo has already been deducted), and the remainder shows the amount necessary for the tannic acid in the bark, or other material; and the relation of the permanganate solution to a standard solution of tannic acid being known from the oxalic acid test, the percent-

* No. 331, p. 5283-4, and No. 339.

† *Journal*, vol. iv., Nos. 1 to 4.

‡ *Journal American Chemical Society*, vol. iii., No. 12.

* This solution is prepared by mixing the half pound of sulphuric acid with a pint and a half of water and allowing the mixture to cool, when it may be preserved in a glass stoppered quart bottle.

age is readily calculated, as the following example will illustrate:

We will assume that 25 c. c. of our oxalic acid solution (equivalent to 0·05 gramme tannic acid) required 16 c. c. of permanganate solution; and with the bark decoction, 12·8 c. c., after the amounts necessary for the indigo and matter other than tannic acid have been deducted. This 12·8 consequently equaled 0·04 gramme of tannic acid, as 16 : 12·8 :: 0·05 : 0·04, and the percentage in the material, of which 20 grammes were employed, is 8 per cent., as 1,000 c. c. : 25 c. c. :: 20 grammes : 0·5, the amount of bark in 25 c. c. of decoction, and 0·5 : 0·04 :: 100% : 8%.

For the determination of gallic acid we require two additional solutions. The first, a standard solution of gallic acid, prepared by dissolving 0·2000 gramme pure crystallized gallic acid in 100 cubic centimeters pure water; its relation to the permanganate solution is then determined in exactly the same manner as with the oxalic acid.

The second, a saturated solution of bichloride of mercury, made by digesting two ounces of that salt in a pint of water, and preserving in a well stoppered bottle labeled "Poison!"

A 250 cubic centimeter measuring-flask is also required.

The amount of gallic acid in well-seasoned dry hemlock bark is about two per cent., depending somewhat upon the soil on which it has grown, and the manner in which it has been collected and dried, larger percentages generally indicating poorly seasoned barks, and a corresponding loss of tannic acid. In the liquors it occurs in corresponding proportions, and in spent barks it is generally absent. Spent liquors frequently contain one-half per cent., especially when old and sour; or if they have been rinsed, even more. As these percentages are so much less than those of the tannic acid, correspondingly larger quantities of the solutions should be operated upon, and the liter of decoction prepared for the tannic acid determination will answer for both.

The first titration is upon 25 cubic centimeters as in the other instances, and the result equals "total oxidizable matters" in 0·5 gramme of bark. Five hundred cubic centimeters of the decoction is then taken, and to it is added 100 cubic centimeters of the copper solution and 400 cubic centimeters of water. After agitation this is filtered, and 50 cubic centimeters titrated exactly as in the tannic acid determination; this result will be "matters other than tannic acid," and consequently includes the gallic acid. Two hundred cubic centimeters of the filtrate is placed in a 400 cubic centimeter flask, and sulphuric acid is run in until it is perceptibly acid; about 50 cubic centimeters of the necessary solution and sufficient water to fill the flask up to the mark are then added, and after thorough agitation the mixture is filtered, and 200 cubic centimeters of the filtrate titrated with permanganate in the usual manner. The result, less the amount necessary for the 25 cubic centimeters indigo solution, is subtracted from twice the amount necessary for the "matters other than tannic acid," and the remainder is the amount necessary for the gallic acid in one gramme of the material used, and from this the percentage is calculated as in the tannic acid determination.

OXYGENATED WATER.

By M. HANRIOT.

IF dilute oxygenated water is heated in a retort, a small portion distills over with the water, while the larger part is concentrated in the retort. The decomposition is null until the concentration exceeds 12 volumes. One hundred grammes oxygenated water at 15 volumes on evaporation in the water bath yielded 30 grammes of water at 58 volumes, and 9 grammes of water at 72 volumes. In a vacuum there is little decomposition until a concentration of 200 volumes has been reached.

Oxygenated water freezes very readily, and the crystals are formed by ice containing oxygenated water interposed. By successive congelations oxygenated water may be strongly concentrated, but after about 70 volumes it no longer congeals in a mixture of ice and salt. If exposed to the intense cold produced by methyl chloride, the liquid congeals to a kind of jelly formed of small crystals impregnated with liquid, and on letting them drain we obtain a more concentrated oxygenated water, up to 137 volumes. Oxygenated water is acid to litmus; it conducts electricity better than does water. At the positive pole nothing but oxygen is obtained. At the negative pole is given off a mixture of oxygen and hydrogen in variable proportions. The author has studied the action of oxygenated water upon a great number of organic bodies, especially upon non-saturated compounds, and he never finds it behaving like dihydroxyl. Its oxidizing action appears most distinct in the aromatic series. It oxidizes benzol to phenol, then to pyrocatechin, and to a body which the author believes to be pyrogallol. There are two methods of determining hydrogen peroxide: either directly, by determining the volume of oxygen given off on its decomposition, or indirectly by means of standard solutions.

ANALYSIS OF BUTTERS.

By M. PIALLAT.

THE hydro-cupro-ammonium reagent is prepared by putting into a glass 100 grammes of pure copper sulphate, coarsely pounded, adding 320 grammes of distilled water, and then immediately a small quantity of ammonia, stirring with a glass rod, and then adding ammonia, drop by drop, constantly stirring. There is formed a greenish blue precipitate, while copper sulphate remains in solution. At the end of the experiment, when there is no longer any precipitate formed, the ammonia should be only faintly manifest to the smell. Filter, wash the moist precipitate with distilled water until the washings run through colorless. The precipitate is then dried at a temperature not exceeding 25°, and finely powdered. For the qualitative analysis are taken two grammes of butter (which must be made in the laboratory to insure that it is genuine) spread out on a glass plate, and two centigrammes of the reagent are incorporated with it by means of a flexible steel spatula. The mixture takes a light turquoise-blue color. The butter is then scraped up with the spatula and deposited on another glass plate, spreading it out so as to judge its color. This is then the standard with which the sample in question is compared. This latter is treated in the same manner, and if it contains margarine it will take a greener and more intense color. One-tenth of margarine is thus perceptible to the eye, and the more the butter contains the more the color will differ from that of the standard. To render this method quantitative, 11 standards are prepared: No. 1, pure. No. 2, mixed with 1/2 margarine. No. 3, with 1/3. No. 4, with 1/4, and so on down to 1/10. These are all treated with the reagent as above, and the sample in question being likewise so treated, its proportion of margarine may be found by comparing the colors. Such standards must be prepared fresh daily.

AN IMPROVED TOURNIQUET.

DR. RICHARD DAVY writes as follows to the *Lancet:* As considerable inconvenience has resulted to surgeons and dressers from the want of a good compressor and an easily acting clip for the fixing or freeing of the elastic cord, I have recently introduced the following plan of a tourniquet for general use in the Westminster and other operating theaters. The subjoined drawing

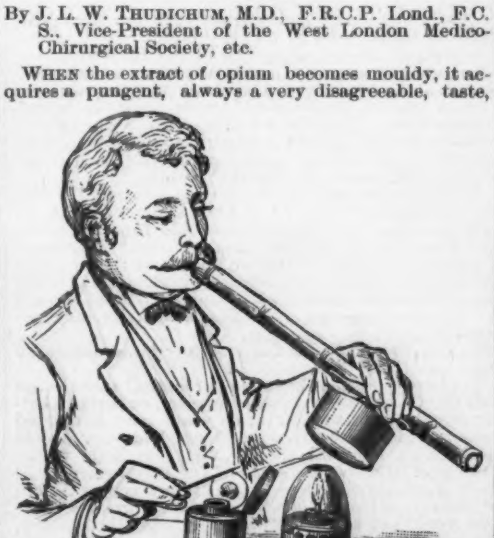
illustrates the tourniquet, as well as its application over the femoral artery. The elastic cord is fixed in the T-shaped compressor by a concealed bullet in the cord, which prevents the cord pulling out one way only, but allows the cord to be withdrawn for purposes of cleanliness through a round hole at the base of the slot. This slot is cut deep in the handle of the T, and the cord in a state of tension is most readily fixed or liberated, the act of letting the elastic cord go in the slot being sufficient to make it secure. The cord may be used either as a one-ended or double band. By allowing the elastic cord to wind over the arms of the T, the compressor is nicely fixed for the use of the slot. This mechanism can be adjusted so tenderly that I have used a very small one for combating the nuisance of incontinence of urine, by applying the compressor under the urethra and the cord (doubly clipped) around the penis.

Messrs. Wright and Co., of 108 New Bond street, W., are the makers. Although in amputations the skilled thumbs of an assistant may be very good, yet I venture to think that the utility of this mechanical arrangement may be proved in urgent and not infrequent occasions.

ON OPIUM SMOKING AS A THERAPEUTIC POWER.

By J. L. W. THUDICHUM, M.D., F.R.C.P. Lond., F.C.S., Vice-President of the West London Medico-Chirurgical Society, etc.

WHEN the extract of opium becomes mouldy, it acquires a pungent, always a very disagreeable, taste,



The opium pipe arranged for pyrolytic inhalation, the annular bead of extract being kept heated over the lamp while the smoker draws air through the central aperture.

when subjected to pyrolysis. Pure, fresh extract of opium, particularly of best Smyrna, used as soon as possible after the harvest, has a most agreeable flavor, and its smoke, if properly produced, is purely aromatic, absolutely mild so as to produce not the slightest irritation, even in the most delicate parts of irritated air passages, and leaves, after a short time necessary for diffusion, no trace of its odor in rooms or upon the persons who have inhaled it.

That the effect of opium smoking is, on the whole, that of its alkaloids was first proved by two French inquirers, MM. Descharmes and Benard. But there are mixed with a small portion of volatilized morphia other pyrolytic products, arising from the decomposition of true extractive matter, which also exercise an agreeable and particularly a stimulatory action on the nerves of the smoker. This can be proved by passing the vapors through an absorbing medium, condensing the solution, and applying the well-known and any desirable tests.

The effect of the vapor is almost instantaneous. It produces a sensation of warmth, and then of slight contraction over the whole pneumogastric region. The stomach is felt in motion the more, the fuller it is. If it has been uneasy from long retained food, the relaxation of the pylorus produced by the vapor allows the spasmodically retained chyme to pass, and ease is at once restored. The effects described presently pass into a sensation of general comfort, any sense of fatigue disappears, evidently on account of the widening of the whole arterial system. At least in all cases which have been observed, the pulse at the wrist became much larger and fuller. In cases where pain and uneasiness have caused the pulse to be small and quick, the relaxing effect is best observed. As the effect of the vapor lays hold of the system, any pain is diminished, and, with continued smoking, if the pain was severe, extinguished. Of course the patient must be kept quiet, and, if possible, sent to sleep, as in the case of the application of opium by the mouth, to obtain the best and most lasting effect. If the patient is kept excited by upright position, light, noise, conversation, etc., a certain amount of anæsthesia and euphopia is no doubt also produced, but the sleep-producing effect of opium is reversed, and wakefulness, lasting for many hours, results. In other words, the tonic effects of opium then prevail over the sedative effects—an apparent paradox, but an undeniable fact, which any experimentalist can observe upon himself. We may say, in summary manner, that the pyrolytic vapor of opium is indicated in all cases in which therapeutical experience indicates the use of opium and morphia. This is the case mainly *in painful affections*, in which the removal of pain alone is a great boon, and contributes to the effect of other specific measures and remedies directed against the essence of the disorder.

All *neuralgias*, without exception almost, are treated as well and successfully by the pyrolytic vapor as by any other form of opium. But in most varieties the pyrolytic vapor is preferable: 1. Because it is more immediate in its action. 2. Because it can be gradually increased until the desired or necessary effect is produced. 3. Because it produces less sickness and less constipation than opium taken by the mouth or incorporated subcutaneously. 4. Because it can probably not be inhaled to any dangerous extent. On this latter part of the subject a good many experiments have been made, which show that a dangerous intoxication by opium vapor cannot be reached by the smoker at his will.

The pyrolytic vapor acts the quicker, the nearer the seat of the disorder to be combated is to the brain; it acts much slower on parts at a distance from the brain, but the degree of relief, though obtained later, is the same. The most direct relief is obtained in neuralgias of the head, hemicrania or tic douloureux, or less typical violent pains in eyebrows, in eyes, ears, in the nasal cavity, in the throat, in the chest, bronchial neuralgia, intercostal neuralgia and pleurodynia; sciatica of the severest forms, such as not rarely tortures diabetic patients; the cutaneous neuralgias of excitable subjects slightly dyscratic. Lead colic, rheumatic affections, the pains of cancerous tumors, of cicatrices, are all arrested easily and agreeably by the use of the pyrolytic vapor.

Similarly, many patients suffering from inflammation are benefited in a remarkable manner. Marvelous is the effect of the vapor upon a common cold, so-called cold in the head, coryza, an inflammation of the mucous membrane of the nasal cavity, called after the anatomist who first accurately described it the Schneiderian membrane. The vapor stops the sneezing and the irritation or tickle thereto, the profuse secretion from the nose, and the sense of injury to the nervous system, the running of tears almost instantaneously; sleep, previously precarious, is sound; and the cold passes directly from the crude into the ripe or abortive stage, so that an indisposition which might have lasted a week or a fortnight is overcome in the time necessary for the restoration of the lost and injured epithelium. When the cold in the head is coupled with one in the chest, the effect of the pyrolytic vapors is equally direct. Irritation, coughing, uneasiness, febrility, cease at once; the secretion from the lungs assumes the thick condition of the stage of resolution; with quiet nights and relatively easy days the patient retains strength and appetite, and soon recovers. A catarrh of a fortnight's duration has been known to be stopped by one inhalation applied at a period when the irritation was yet great and cough incessant. Nothing can show better than the direct effect of the pyrolytic opium vapors how many disorders of the respiratory passage are the result of mere nerve irritation by trifling causes, which, being calmed, give the opportunity for immediate recovery. Many common catarrhs of the lungs lead to emphysema by the mere force of coughing, excited by the bronchitis; these excessive results of in themselves not very dangerous indispositions are mostly obviated by the use of the pipe.

In pleuritis and pneumonia, if pain and dyspnœa do not permit forced inhalation, in peritonitis, cystitis, in orchitis, in carbuncle, and a number of other painful inflammations, the pyrolytic vapor should be directly used. Of course, when respiration is shallow or difficult, either on account of pain or of loss of room in the lungs, or of loss of muscular respiratory power, the vapor cannot be used, as the person who is to use it must produce it himself, which, in the cases alluded to, he has not the power to do. In these cases the subcutaneous application of morphia is far preferable to the pipe. Laryngeal cough or hyperæsthesia of the larynx, which sometimes, by the persistent concussion of the abdominal walls, inflicts upon the sufferer the mechanical injury of one-sided or even bilateral inguinal rupture, is immediately stopped by the vapor. Such cases are frequently treated by mechanical and chemical applications to the larynx, continued for weeks, when sedatives would make a speedy end of the trouble. Sneezing of all kinds, but particularly sneezing of the spasmodic variety, is quickly suppressed.

There is a particular irritability which seizes men of business or professional pursuits in the morning; they sneeze, their eyes water, and they manifest all the symptoms of a cold; after a time they become febrile, and then, after the use of several handkerchiefs, and perhaps some alcoholic stimulant, the attack passes off, leaving the sufferer much diminished in strength, and not very fit, or sometimes quite unfit, to begin his day's business. In many such cases the opium pipe has given immediate relief, and after some continued use cured the patient of the disposition to the attack. Nervous or neuralgic asthma is prevented or arrested by the vapor better than by the ordinary means of paper cigarettes or herbal fumigations. The pseudo-asthmatic attacks of patients afflicted with chronic emphysema are eased or stopped more immediately by the pyrolytic vapor than even by chloroform or ether, or a mixture of the two with alcohol, and much quicker than by the opiates which these patients always take by the mouth. Even the spasmodic attacks of asthmatic breathing, affecting patients with kidney disease (albuminuria) at night, are eased or prevented by the use of the pipe, in all cases in which the lung is not compressed by effusion, and the bronchia are not obstructed by frothy mucus. The existence of much bronchial mucus prevents the vapor from acting quickly; on the other hand, the vapor helps to effect expectoration by loosening the phlegm and widening the elastic limits of the lung-tissue. In gastralgia and in the severe affection which may be termed a gastric neuralgia, as it centers in or around the cardiac ganglion, causes men to sink almost in collapse, to be bathed in sweat, to almost lose their pulse, and to present all symptoms of dangerous suffering; in the same affection coupled with hemiopsia, a curious and rare affection of the brain, of short duration, in which the patients see with either eye, only half of the object they are contemplating, such as half the face of a person across the street, but not the other half, the pyrolytic vapor gives instant relief.

The opium vapor tones down excitement or excitability of the spinal marrow, such as the not rarely distressing affection termed popularly fidgets, which follows either meals, or accompanies pregnancy or abdominal tumors, or follows strong physical exertion, walking, riding, hunting. In all cases of excessive fatigue from physical exertion, including the labor of parturition, the pyrolytic vapors are procurers of immediate repose and conditions of quick recovery.

Excitement of the brain, idiopathic nervous sleeplessness, are counteracted by the vapors better than by other sedative preparations; the sufferer may repeat the use during the same night. The sleeplessness of acute and chronic diseases yields also to the vapor. Upon some persons, however, the vapor has a tonic effect only, so that it produces calm, but no sleep; on the contrary, it produces sometimes sleeplessness, when used in insufficient doses, but this condition is not disagreeable, but on the contrary is a waking repose of an agreeable nature, not accompanied with tossing about or turning from side to side. In pulmonary consumption the inhalations are of great value, by allaying the ceaseless irritation, preventing emphysema and bronchectasis, and producing sleep. But enough has been said to show the rare power of this splendid and safe therapeutic agent.—*B. & C. Druggist.*

[SCIENCE.]

IMMORTALITY IN MODERN THOUGHT

IT will be admitted, we think, that the tendency of modern science is materialistic. This is especially true of biology. In fact, to many the doctrine of correlation of vital with physical forces, and the doctrine of derivative origin of species, seem little short of a demonstration of materialism. Thus materialism has become a fashion of thought; but, like all fashions, it has run into excess, which must be followed by reaction; we believe the reaction has already commenced. Science sees now, more clearly than ever before, its own limits. It acknowledges its impotence to bridge the chasm between the physical and the psychical. We pass from physical to chemical and from chemical to vital without break. All is motion, and nothing more; also, in the region of the vital, we pass from sense impression through nerve-thrill to brain-changes, and still we find only motions. But when, just here, there emerge consciousness, thought, will, the relation of these to brain changes is just as unimaginable as the appearance of the genie when Aladdin's lamp is rubbed.

It is impossible to emphasize this point too strongly. Suppose a living brain be exposed to an observer with infinitely perfect senses. Such an observer would see, could see, only molecular movements. But the subject knows nothing of all this. His experiences are of a totally different order, viz., conciousness, thought, etc. Viewed from the outside, there is nothing but motions; viewed from the inside, nothing but thought etc.—from the one side, only material phenomena; from the other, only psychical phenomena. May we not generalize this fact? May we not extend it to nature also? From the outside we find nothing but motion. On the inside there must be consciousness, thought,* etc., in a word, God. To bridge this chasm, whether in nature or in the brain, Science is impotent. As to what is on the other side of material phenomena, she is agnostic, but cannot be materialistic.

Admitting, then, in man a world of phenomena which cannot be construed in terms of motion, and which for convenience we group under the name of "spirit," is the group permanent? Is the spirit immortal? On this subject, Science can say absolutely nothing. The field is therefore open for evidence from any quarter, and of any degree. Some of these evidences, though not given by Science, are at least suggested by lines of scientific thought. A few of these we briefly mention:

1. We have said that consciousness and thought lie behind material phenomena, in nature and in the human brain. In the one case we call it God, the divine Spirit; in the other, the spirit of man. Now, does not this identity or similarity of relation to material phenomena imply, or at least suggest, *similarity of nature*, and therefore immortality for the spirit of man?

2. Individual human life passes through its little cycle of changes, and quickly closes in death. If this be all, then *for the individual*, when all is done, it is precisely as if he had never been. "Yes," answers the Comtist, "for the individual, but not for humanity. Every human life leaves a residuum which enters into the life and growth of humanity. It is a glorious and unselfish religion thus to merge one's self into the only true object of worship—humanity." But, alas! the cycle of humanity also closes; and for humanity too, when all is done, it will be precisely as if it had never been. "But the earth—the cosmos—abides." Yes, but only a little longer. Science declares that the cycle of the cosmos must also close. And then, when all is done, after all this process of evolution reaching upward to find its completion in man, after all the yearnings, hopes, struggles, and triumphs of man, what is the outcome? It is precisely as if the cosmos had never been. It is all literally "a tale told by an idiot, full of sound and fury, signifying nothing." Not only heart, but reason, revolts against such a final outcome. If we believe that reason underlies the phenomena of the cosmos, we cannot accept such a result. We cannot believe that the cosmos has no intelligible end. But what intelligible end is there conceivable, unless something is finally attained which is not involved in a cycle, *i. e.*, unless man is immortal?

3. There are three primary divisions of our psychical nature, viz., sense, intellect, and will. There are three corresponding processes in making a complete rational philosophy, viz., (1) instreaming of impressions of the external world through the senses (facts); (2) elaboration of these into a consistent whole by the intellect (knowledge); (3) outgoing of this knowledge in activity (conduct). Now, a true working theory of life must satisfy all these. But scientific men are apt to think that only 1 and 2 are necessary; that true facts elaborated into consistent theory is all we need care for. Theologians, on the contrary, seem to think only 2 and 3 necessary; they elaborate a theory of life consistent with itself, and apparently satisfactory in its application to conduct, but are less careful to test its harmony with facts derived from the senses. But all three are necessary.* The first furnishes material; the second constructs the building; the third tests its suitableness for human habitation. All admit that successful application to art is the best test of true theory. But conduct is the art corresponding to our theory of life, and therefore the *test of its truth*. Now, is not immortality as an element of our theory of life in the highest degree conducive of right conduct? Is it not a useful, yea a necessary, element in a working hypothesis?

4. But it may be objected, animals, too, have brains; in them, too, we find evidences of something like consciousness and thought. Are they, too, immortal? If so, where shall we stop? We pass down by sliding scale, without break, to the lowest verge of life. Shall we stop here? No; for vital is transmutable into physical forces. Thus all is immortal, or none. Thus hope of immortality vanishes, as it were, by evaporation.

This objection, though serious, is, we think, not fatal. To make our view clear, we use an illustration taken from biology. May we not imagine that in animals spirit is in embryo in the womb of Nature, unconscious of self, and incapable of independent life; and that in man it came to birth—a separate spirit—individual, conscious of self, and capable of independent life, on a new and higher plane? According to this view, geological time is the period of gestation, evolution is the process of development, and the appearance of man the act of birth.†

JOSEPH LE CONTE.

* This thought is admirably presented by Johnstone Stoney, *Nature*, vol. xxxi., p. 422.

* Reflex Action and Theism. William James. *Unitarian Review* for November, 1881.

† *Princeton Review* for November, 1878.

METEOROLOGICAL SOCIETIES.

WITHIN the past few years, in various parts of the country, there have been established a number of local meteorological societies. At first this would seem to be a good move on the part of the public to become enlightened in this interesting branch of science. But when we learn of their narrow basis of action, the narrow grooves in which they move, and the expense attending them, it is quite evident that they have not been established or conducted on such practical principles as would lead to very satisfactory results; and this I say in all due deference to the leading spirits, who have with apparent zeal labored to establish these societies. From their published statements made from time to time, a regular society with dues, etc., is first inaugurated. Then the members provide themselves with the various meteorological instruments, barometer, thermometer, etc., and send in to some headcenter daily, weekly, or monthly reports.

Where people have no knowledge of the advanced steps of the meteorology of to-day this seems to be very good, and it is almost impossible for them to see the absurdity of it. But there is one thing most important to learn in this respect, and that is, it is *impossible* to study this science within a small territory. No single State in the Union is large enough for this purpose—not even Texas, with its immense territory.

It is never well to find fault or to criticise unless we have something better to offer.

In place of establishing meteorological societies on this plan, I would respectfully suggest, or perhaps better repeat, for I have, for some years past, advocated meteorological clubs, that intelligent bodies of people unite in an informal manner, and contribute to the taking of the weather-map. The Government sells these maps at cost price—two cents per copy. A club of a dozen or twenty persons, or even a greater number, would not be impractical. The larger the number, the less the individual expense. A club of twenty persons would require only an expense from each of two cents every twentieth (20th) day; a club of thirty (30), about two cents a month.

There is no way under heaven to study meteorology but by these maps. If I may be allowed the liberty of the expression, they are *the geography of the atmosphere*; as it were, the beholder is taken up to some exceedingly elevated point, where he can view at once the whole area of the United States, and see the movement of the atmosphere over its immense territory.

As one becomes familiar with this, he will begin to grasp the plan of the Grand Architect of the universe in relation to the atmosphere of our planet.

He will see that there are two factors, high and low barometer, technically called "High" and "Low;" that these move over the surface of the earth, on general lines, from west to east.

The special point of observation is to note these movements and their effect. In order to do this, we must study well the explanation and characters (or the "Legend"), whereby to read and understand the maps.

This may seem laborious, but in practice it becomes quite an easy matter.

From experience in instructing others I will warrant that any intelligent person will in two weeks' time be able to read the map almost at a glance. The detail is not difficult to master. Let the student, however, go slow at first. He will observe that the movement is on general lines, from the west toward the east; that "High" is relatively a cold factor, for the simple reason that the movement of the air is always from this center, and on that account it has not much opportunity to become heated. "Low" is warm or cold in proportion to its latitude. As the wind is toward "Low," it follows, if it is on a high or north line of latitude, it will cause south winds, which are warm; if on a south line, north winds, which are cold.

Particular attention must be paid as to whether the wind is from a positive and near bank of "High," or whether the center of "High" is a long distance off, and the wind allowed to pass over a very extensive track of land, whereby it may become heated by contact with the surface of the earth.

I repeat, the only way to understand our weather system is by the weather map.

Those who desire to become weather wise can do so at very slight cost. Let them club together, furnish two cents a day, subscribe for the map, and they will have all that it is possible or desirable to obtain.

Instead of expensive meteorological societies, with their heavy organization and dues, have simple meteorological clubs, with no further expense than the slight cost of the daily map.

Washington, D. C., May 7, 1885. I. P. NOYES.

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